CORPS OF ENGINEERS, U. S. ARMY

MISSISSIPPI RIVER COMMISSION

AIRPLANE LANDING MAT INVESTIGATION
TESTS ON STEEL, PIERCED TYPE, M7

TECHNICAL MEMORANDUM NO. 3-266

WATERWAYS EXPERIMENT STATION

VICKSBURG, MISSISSIPPI

DECEMBER 1948

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Introduction

1. Engineering tests were conducted by the Waterways Experiment Station on airplane landing mat, steel, pierced type, M7, during the period 15 December 1947 to 30 April 1948. The tests were assigned by the Engineer Research and Development Laboratories, Corps of Engineers, the plan of tests and the funds being provided by that agency. As a matter of record, letters of authorization and the plan of tests are included in this report as an appendix.

Objectives and Scope

2. The primary objective of this study was to determine if a single layer of the M7 landing mat is capable of sustaining traffic simulating that imposed by military aircraft with 70,000-lb dual wheel loads during one year of normal operations on a field airdrome in a theater of operations. An additional objective was the determination of the effect on the M7 mat of traffic with a 50,000-lb single wheel load. To accomplish these two objectives test sections were constructed and surfaced with the M7 mat. Control sections were also placed in which the earlier M6 type mat was used for comparison. Traffic was applied to both types of mat with the designated wheel loads using a runway load testing cart. Another objective of the tests was to record data that could be used to determine if the M7 mat complies with the military

characteristics as outlined in project AC 680 (now 8-69-04-002). This was done by measuring certain physical characteristics of the mat designated in the plan of tests. Tests were also included to determine the relative rates of wear of 26- by 6.6-in. airplane tires on M7 and M6 landing mats and on asphaltic concrete, and to obtain limited information on the distribution of stresses and deflections in the subgrade under the M7 and M6 mat.

Physical Characteristics of M7 Mat

Packaging

3. Except for minor modifications, the M7 landing mat used in these tests was fabricated in accordance with Engineer Research and Development Laboratories drawing E 7146-1 "Airplane Landing Mat, Steel, Pierced Type M7." It was manufactured by the United Steel Fabricators, Inc., at their Wooster, Ohio, plant and was received as a rail shipment at Vicksburg on 15 December 1947. The shipment consisted of nine bundles of mat with single end connectors and eight bundles with double end connectors. Each bundle contained fourteen whole planks and four half planks. The individual planks were stacked neatly with all corresponding bayonets pointing in the same direction in the bundles. In this manner almost perfect nesting was secured. Each bundle was securely bound at four points with heavy box strapping. There was considerable timber blocking in the car to keep the bundles separated and prevent their being shifted about when the car was switched. However, this blocking was not attached to the bundles and was not considered part of the packaging. When received all of the mat was in perfect condition, but some of the bayonets were bent

by the cable slings used in unloading and handling the bundles at the Waterways Experiment Station. Plate 1 shows a bundle of mat as packaged for shipment. Following is a tabulation of package data:

	Gross Wt (lb)	Tare (lb)	Length	Width	Thickness (in.)	Cubage (cu ft)
Maximum	1860	5.2	12' 1"	1' 9-1/2"	7-5/8	15.04
Minimum	1845	4.9	12' 1"	1' 9-3/8"	7-1/4	14.25
Average	1855	5.0	12' 1"	1' 9-13/32"	7-3/8	14.50

Plank dimensions and weights

4. The mat was manufactured from 11-gage sheet metal. Micrometer measurements on four planks selected at random from four different bundles ranged from 0.1210 in. to 0.1230 in. The average thickness was 0.1222 in. These measurements were made after the paint had been removed. Panel lengths were nearly constant at 11 ft 11-3/4 in. for pieces with single end connectors and 12 ft 3/4 in. for pieces with double end connectors. The individual panel width varied from 1 ft 8-15/16 in. to 1 ft 9-1/32 in., and averaged 1 ft 9 in. The individual plank weight (including paint) ranged from 112.5 lb to 119.65 lb, with an average weight of 115.60 lb. Plate 2 shows M7 plank with single and double end connectors and an M6 plank.

Chemical composition

5. The Materials Branch of the Engineer Research and Development Laboratories made chemical analyses of the metal in the M7 and M6 mats used in these tests. The results are tabulated below:

	M6	M7
Carbon	0.11	0.11
Phosphorus	0.018	0.005
Manganese	0.16	0.25

The following quotation is from a descriptive paragraph of the ERDL report on the chemical analysis of the M6 sample. "The results show that the composition of the test sample (M6) is similar to that of the 1695 sample (M7); whether the physical properties of the two samples are similar cannot be determined from these results." The results of deflection tests also made by the Engineer Research and Development Laboratories are shown on plate 3.

Preparation of Test Site

6. From advance study of the plan of tests and from knowledge of conditions in the test area it was known that the natural moisture content of the material to be used for the subgrade would be in excess of that desired and that drying would be necessary. The construction of the test lanes was scheduled during the winter months which are normally too rainy for drying soil. For this reason the test lanes were located under an airplane hangar approximately 162 ft long by 148 ft wide which is part of the plant facilities available at the Waterways Experiment Station for this type of work. Plate 4 is an exterior view of this hangar and plates 5 and 6 are interior views. This was the first test of this nature conducted under a hangar, and it was thought that sufficient protection would be afforded to permit construction and testing during the rainy weather. While the protection afforded was extremely helpful, it did not prove to be a complete solution to the problem of conducting tests of this nature during the winter months. Construction of lanes was hampered to some extent by winter weather because there was not sufficient space under the hangar to dry material after the first

lane was completed. Since sunshine was excluded from processing areas under the hangar (during construction of the first lane), material dried more slowly than it did outside. Also, the high, open ends of the hangar permitted rain and snow to be blown into the test area during storms. However, it was possible to protect the lanes after they were constructed. Also testing was conducted almost without delay due to weather conditions. Without the hangar, the tests could not have been completed during this period, and it would have been necessary to delay them until summer when weather conditions would have been more favorable. Test lanes 1 and 2 were laid out as two parallel test lanes approximately 50 ft wide by 100 ft long as shown on plate 7. Test lane 3, which was constructed after lanes 1 and 2 were completed and tested, was placed on the site of test lane 2, except that the center line of the lane was shifted 10 ft nearer the center line of the hangar.

Test lane 2

7. Due to minor changes in the program after preparation of the test site was started, test lane 2 was built and tested before lane 1; hence it will be described first. The plan of test directed that a subgrade be built with a California Bearing Ratio of 15 per cent and that any deviation therefrom be on the high side. It was anticipated that considerable compaction would occur under the test traffic, and especially under the 50,000-lb single wheel load with which this lane was to be tested. To prevent the development of excess pressure in the pore water and early subgrade failure, it was decided to compact the subgrade material with a comparatively high compactive effort and at a moisture content slightly on the dry side of optimum. The soil used was a clayey

silt available on the Waterways Experiment Station grounds. The entire test lane was excavated to a depth of 2.5 ft below the proposed finish grade line. The soil was processed and dried to approximately 16 per cent moisture content, and compacted in the lane in five 6-in. lifts. Compaction was accomplished with 24 passes of a 60-in. sheepsfoot roller so loaded that the pressure intensity under the feet was 500 psi. Passes were applied in a pattern that gave uniform coverages by the treads of the tow tractor as well as by the roller. The resulting subgrade was quite uniform throughout the lane, with average soil conditions as tabulated below.

Depth Below Surface (in.)	Moisture - Per Cent of Dry Weight	Unit Weight (lb/cu ft)	In Place CBR
2	15.9	108.1	25
14	15.5	104.0	22
26	16.2	105.1	18

The finished lane was laid out in two equal sections, numbered 3 and 4, approximately 50 ft square. Section 3 was divided into two subsections, each 25 ft long by 50 ft wide. On the first subsection, designated 3a, M7 mat with double end connectors was laid with one-half of the locking lugs (alternate lugs) bent down into locking position. On the second subsection, designated 3b, M7 mat with double end connectors was laid with all locking lugs engaged. For comparative purposes, M6 mat was laid on all of section 4. Plate 7 shows the arrangement of the mat. Since bayonet spacings and designs on the two mats were different, M6 mat could not be joined directly to the M7 mat. To effect a secure joint between the two mats, one line of M7 planks and one line of M6 planks were ripped and the half planks were welded together in the field to form what amounted to a single line of planks with the two types of bayonets. Plate 8 shows this

welded joint. The mat was securely anchored at each end of the lane by cables laced through the tubulated holes and connected to deadmen buried in the subgrade.

8. Laying areas and weights. After the mat had been placed in the lane ready for traffic testing, the actual area covered by 56 planks was measured and the average laying area per plank was determined. The average laying area per plank was divided into the plank weight to determine the average weight per square foot of mat. The results showed a laying area of 18.27 sq ft per plank and a weight of 6.32 lb per sq ft of mat. The average laying area of a bundle (including half planks) was 292.3 sq ft. The weight of M7 mat is proportional to the thickness of sheet used in its manufacture. As stated in paragraph 4, the average thickness of the plank tested was 0.1222 in. Since 11-gage sheet may be expected to average about 0.1196 in., the average weight of M7 mat in quantity production would be $\frac{1196}{1222}$ x 6.32 or 6.19 lb per sq ft or slightly less than the 6.25 lb per sq ft maximum called for in the plan of tests. Since the area of each plank is about 21.5 sq ft, the effective laying area is about 85 per cent of the nominal area of a group of planks. For comparison the M6 planks weigh about 5.44 lb per sq ft of mat and each plank has a laying area of 12.5 sq ft.

9. Laying speed. Records were kept of the rate at which the M7 mat with both single and double end connectors could be placed in the lane, under different working conditions. Corresponding records were kept on the M6 mat for comparison. It was anticipated that the double end connectors would add slightly to the difficulty and time required for placing the mat. However, this did not prove to be the case, since no

actual difference could be noted between the placing of the two types of mat. It was found that any slight deformation of one or more bayonets on a plank would cause trouble in placing the mat and reduce the rate of progress. Also, it was found necessary to drive at least 90 per cent of the planks into position for locking, and that there was no convenient place to strike the plank with a hammer. This situation was overcome by placing a tool similar to a coarse calking chisel at the end of the mat and striking this tool. A crew of six men and one foreman could place the M7 mat at a sustained rate of 172 sq ft per man hour when the planks were distributed on the lane within easy reach, or 112 sq ft per man hour when the men carried the planks from a stock pile 110 ft from the center of laying operations. The M6 mat carried from the same stock pile was placed at a rate of 150 sq ft of finished mat per man hour. It should be kept in mind that while considerably more time and energy are required to place a single unit of the M7 mat than are required to place one unit of M6 mat, the unit of M7 mat covers 46 per cent more area than the M6. Another point of difference is that when a plank of the M7 mat is driven into position there is no end connector to place as is required on the M6, but the locking lugs must still be bent into position on the M7. Workmen agreed that the M6 mat was easier to place than the M7 mat. Increasing the number of men in the crew resulted in a slight reduction in the square feet of mat laid per man hour.

10. Removal or replacement of plank. After 528 coverages had been applied to test lane 2 one plank of the M7 mat was removed and replaced to check the feasibility of replacing damaged mat in runways. The following operations were performed in connection with the removal of this

plank:

- a. The plank being removed was disengaged along one side by cutting away the band carrying the horizontal bayonets of the two adjacent planks on that side.
- b. All end connector bayonets of the joint at the underlapping end of the plank being removed were cut away.
- c. All locking lugs on the plank being removed were bent upward until disengaged.
- d. The plank was driven backward until all remaining bayonets were in position to come out of the slots.
- e. The portion of the plank still under the overlapping end of the adjacent plank was cut off.
- f. The plank was raised to disengage the bayonets, and removed.

This method of removal was predicated on reusing the same plank. Otherwise operation b would have been omitted and operation e would have preceded d. This, of course, would simplify the work of removal slightly. The only difficult operation was driving the plank backward to free the bayonets. The nearly square shoulders left at the bases of the horizontal bayonets fouled at the ends of the bayonet slots and had to be pried out with pointed tools. Plate 26, which shows another feature of the test, also shows this condition. The time required for a crew consisting of one foreman, one welder, and two laborers to remove this plank was 30 minutes. It should be noted that if a large area of M7 mat must be removed, when one row of plank has been removed across the runway, the remainder may be disconnected by simply reversing the placing process.

11. The plank which had been removed was rehabilitated to some extent, and then replaced in the lane. If a new plank had been used, it would have been necessary to cut away a few inches of the underlapping end in order to get it under the adjacent plank. A foreman with three

men replaced the plank in 20 minutes. The closing side joint was made by welding each bayonet of the plank being replaced to the adjacent planks. The end joint where all bayonets had been cut away was also welded. The welding time was 30 minutes. These welded joints held satisfactorily throughout the remainder of the test. Plate 9 shows the metal cut away in order to remove the plank and the appearance of the subgrade after the plank was removed. Plate 10 shows the welded joints.

Test lane 1

12. After lane 2 had been finished and traffic testing almost completed, test lane 1 was constructed. This lane was constructed in the same manner as described above, except that the soil was processed and rolled at a slightly higher moisture content. The following tabulation shows soil conditions of the finished subgrade:

Depth Below Surface (in.)	Moisture - Per Cent of Dry Weight	Unit Weight (lb/cu ft)	In Place CBR
2	16.3	108.0	16
9	15.2	106.9	16
15	14.7	102.9	12
21	16.1	105.8	18
27	17.6	107.6	15

The mat arrangement was the same as that described for lane 2, except that all M7 mat had single end connectors. A layout of lane 1 is shown on plate 7. A small blanket of Prefabricated Bituminous Surfacing (PBS) about 10 ft wide by 12 ft long was placed on the subgrade in subsection 1a of this lane before the M7 mat was laid. Its purpose was to show what effect the underside of M7 mat would have on PBS when used under the mat as a dust preventative and waterproofing agent.

Test lane 3

13. Test lane 3 was decided upon and authorized after traffic testing was finished and no mat breakage had occurred on test lane 1. Requirements for this lane were: (a) that subgrade processing be not more than 18 in. deep to reduce construction time; (b) that the subgrade have a CBR value of 10 per cent or less to induce mat breakage, if possible, at less than 500 coverages. To meet these requirements the subgrade was excavated to a depth of 18 in. and replaced with three 6-in. lifts of processed soil, each compacted by 12 passes of the sheepsfoot roller. It will be noted that this was only half the compactive effort used on the other lanes. The soil for this lane was processed wetter than the other two lanes to insure a lower CBR and quicker failure of the mat. The uniformity of soil conditions obtained on this soft lane was not quite as good as that obtained in the two previous lanes. The soil conditions just prior to the start of traffic are tabulated below.

Section	Moisture Content at			Unit Weight at			In Place CBR at		
	2 in.	8 in.	14 in.	2 in.	8 in.	14 in.	2 in.	8 in.	14 in.
5a (M7)	21.3	19.3	17.0	105.1	105.3	102.9	5	11	10
5b (M7)	21.9	20.7	18.3	103.3	106.9	94.5	3	9	10
6 (M6)	21.5	20.7	19.8	104.1	103.2	98.3	5	9	12

The same sections of mat that had been tested on lane 1 without appreciable damage were dragged intact onto lane 3. Since no braking tests were planned on lane 3, the ends of the mat were left unanchored.

Test Procedure

Braking tests

14. Braking tests were conducted with the 70,000-lb dual wheel

load on both M7 and M6 mats immediately after the mats had been placed, and after enough traffic had been applied to embed thoroughly the mats in the subgrade. During these tests the entire testing unit was towed by an M6 hi-speed tractor. Generally, no power was applied to the wheels of the prime mover which normally tows the load cart in traffic tests. The hi-speed tractor was attached to the load cart by means of a cable long enough to permit its operation entirely outside the test lane. Thus no towing power was applied to the landing mats. The test load cart was started rolling from the ends of the test lane (where the mats were anchored) toward the center. When it was fully under way the brakes were set so as to lock the test wheels, and it was dragged across the section with the tires skidding on the mat. Observations of tire wear and effect on mats were made.

Traffic tests

15. All traffic testing was done with the load testing cart, which is a part of the plant available at the Waterways Experiment Station. This machine can be loaded to gross weights ranging from 24,000 to 150,000 lb on either a single or dual wheel. Plate 5 shows the testing device with a 70,000-lb gross load on dual, 56-in. airplane tires. Lanes 1 and 3 were tested with the 70,000-lb gross load on the dual, 56-in. tires. Lane 2 was tested with a 50,000-lb gross load on a single, 56-in. by 16-in. high-pressure tire. During the traffic tests this machine was driven forward across the test sections. Then, because it was not feasible to turn on the soil outside the hangar (it was muddy during a greater part of the test period) and to save time, it was driven backward as nearly along the same tracks as possible. Average speed in

both directions was approximately 3-1/2 mph. The machine was shifted laterally on each succeeding forward trip until all of the traffic lane had been covered. The operator was able to maintain correct position in the forward direction, but some wandering of the vehicle occurred in the backward direction. To insure more uniform coverage of the traffic lane, the direction of traffic was reversed each day. Throughout the testing program on landing mats it has been noted that in a majority of instances the test sections either failed quickly or successfully withstood 1000 coverages with indications that traffic could be continued almost indefinitely without causing failure. Since 1000 coverages represent nearly unlimited operation, and since it can be shown that normal equivalent traffic on field airdromes in the theater of operation will produce 1000 coverages in one year or less, it is considered that 1000 coverages conservatively represent one year's operation. On this basis failures that occur at some fractional part of 1000 coverages also represent an equivalent approximate service life expressed in months. For example 500 coverages equal 50 per cent of 1000, or 6 months' operation. For test purposes a section of mat is considered to have failed when the surface has become so rough as to appear unsafe for landings and take-offs by airplanes or when mat breakage has become so severe as to present seriou tire hazard.

Tire wear tests

16. A special load cart was improvised for use in these tests. It consisted of an Athey wagon with the tracks replaced by two 26- by 6.6-in. airplane tires, wheels and landing gear assemblies. One of these wheels was set partially under the Athey wagon body, and served as the

test wheel. The other was placed at the end of an elongated axle and served as an outrigger to stabilize the load cart. The tire on the test wheel was inflated to a pressure of 160 psi and the cart so loaded that the tire under test carried 8000 lb. Plate 11 shows the loaded cart behind a tow truck as it was used in the tests. Tests were conducted on three surfaces: M6 mat, M7 mat, and asphaltic concrete. In performing the tests the cart was stopped on the mat or pavement, the wheel bearing the tire under test was locked and the tire was skidded for a distance of 50 ft. Then the brakes were released, the wheel rotated slightly, the wheel locked again, and the tire skidded another 50 ft with a different spot on the tire in contact with the pavement. This was repeated until the tire had been skidded a total of 1000 ft and all of the tread had been subjected to wear by being dragged over the surface. A new tire was used on each surface. The difference in tire weight before and after the test indicated the amount of wear in pounds of rubber lost during the test.

Pressure distribution tests

17. In the pressure distribution tests, M7 and M6 mats were laid over the surface of a test section and the stresses and deflections induced by simulated wheel loads were measured at a depth of 12 in. below the surface. For comparison, the stresses and deflections with no mat on the surface were available from results of studies on the test section constructed as a part of another project at the Waterways Experiment Station. The test section originally consisted of a homogeneous fill 12 ft deep constructed of clayey silt similar to the subgrade used in the landing mat lanes. The CBR of the soil was approximately 10 per cent. Pressure cells and deflection gages were installed at an elevation of

7 ft above the bottom of the fill. Loads were applied at the surface using hydraulic jacks through circular, flexible faced bearing plates. After the loading was completed at the original surface, which was 5 ft above the plane of the cells, the test section was cut down in 1-ft increments and the loading program repeated at each new elevation. During the period of the landing mat tests, the tests on the last increment, which was 1 ft above the plane of the cells, were completed, after which the two types of landing mats were placed on the section, loads applied, and measurements made. Plate 12 shows load applications in progress.

18. The pressure cell installation consisted of 37 Waterways Experiment Station type pressure cells with the majority of the cells 12 in. in diameter by 1 in. thick. The pressure cells consist essentially of an outside pressure collecting face and an inner steel diaphragm. Pressure acting on the face is transmitted through an oil chamber to the inner diaphragm, producing deflection of the diaphragm. The deflection of the diaphragm is measured electrically by means of the change in resistance of SR4 type strain gages cemented to the diaphragm. The change in resistance under the induced stresses was measured with a Baldwin Southwark automatic strain gage reader. More complete details of the pressure cells are contained in the appendix to the report entitled "Certain Requirements for Flexible Pavement Design for B-29 Planes," published by the Waterways Experiment Station in August 1945. The pressure cells were installed on horizontal and vertical planes and on two perpendicular planes, each of which was 45 degrees to the horizontal. The cells were installed so that readings could be obtained

directly beneath the center of the loaded area and at offset distances to where the recorded stress was practically zero.

19. The deflection gages were selsyn motor type gages developed and constructed at the Waterways Experiment Station. This gage utilizes the fact that when a pair of selsyn motors are interconnected, rotation of one of the motors results in an equal rotation of the other. This principle is utilized by attaching micrometer screw thread mechanisms to the motors so that each revolution of the motor drives the threaded pin inward or outward a known distance. Thus the movement of the threaded pin of one of the motors when placed in an inaccessible location can be determined by measuring the movement of the threaded pin on the other motor. In measuring deflections, one motor is attached to a circular flange and buried in the test section at the stated elevation. A stationary reference consisting of a steel rod seated about 20 ft below the stated elevation is installed so that the top of the rod is about 1 in. below the threaded pin in the micrometer screw on the selsyn motor. An associated electrical circuit is included in the system which operates a sound signal when the threaded pin in the buried motor is completely retracted or when the pin is extended to where it touches the reference. Thus the deflection gage may be considered a remote control micrometer. The deflection gages were installed so that the deflection could be measured under the center of the load and at offset distances from the center sufficient to register a deflection of practically zero.

20. The test procedures for these tests consisted of applying loads of 15,000, 30,000, 45,000, and 60,000 lb through a circular plate having a 1000-sq-in. area. The tests were conducted on the mat in an

unbedded condition. A tarpaulin was placed between the flexible face on the bearing plate and the landing mat to prevent damage to the flexible face. The pressures and deflections recorded at a depth of 12 in. for the two types of mat and for no mat are tabulated in table 1. Each value for a pressure represents the average of three consecutive readings. Each value for a deflection represents only a single reading. The values for the major and minor principal stresses and for the angle of the major principal stress were computed from the pressure readings on the four planes. The method of computation is explained on pages 279 through 284 of the report "Triaxial Shear Research and Pressure Distribution Studies on Soils" published by the Waterways Experiment Station in April 1947.

Rolling resistance tests

21. Tests to determine the comparative rolling resistance of the runway test load cart on unprotected subgrade and on airplane landing mat were performed as follows: The prime mover with yoke attached, but without the load cart in place, was towed over the test lane with the prime mover gears in neutral position. The force required to tow this part of the runway load testing device at a uniform speed of approximately 4 mph was measured with a recording dynamometer. Then the load cart with the 70,000-lb dual wheel was attached and the force required to tow the complete runway load testing device was measured. The measurement without the load cart in place was considered as tare, and the difference between the force required to tow the entire apparatus and the tare was considered as the force required to tow the 70,000-lb dual wheel load. These measurements were made on the bare subgrade in lane 2 and on the landing mat both as laid on a new subgrade and after it had been embedded in the

subgrade by traffic. The tests were made at tire pressures ranging from 70 to 120 psi. In each case three or more measurements were made to insure average values. Tests were scheduled at higher pressures, but were eliminated because the results were showing very little effect of tire pressure. The results are presented in table 2.

Test Results

Braking tests with 70,000-lb dual wheel load

22. M7 mat -- not bedded. The tires used in the braking tests had been used previously in traffic tests. However, they apparently were sound structurally, and the treads were still in good condition for gripping the mat surface. In this test the wheels were locked after the cart had moved about 4 ft from the anchored end of the M7 mat section and then skidded a distance of 35 ft across the mat. The force required to tow the load cart across the new M7 mat was approximately equal to the maximum drawbar capacity of the M6 hi-speed tractor and, in order to prevent a stall, a small amount of power was applied to the wheels of the prime mover of the runway load testing device through the last 16 ft of the skid. The end anchor held firm, allowing the mat to creep forward only 3/8 in. at that point. The mat started buckling ahead of the tires after they had skidded approximately 20 ft. The maximum buckle at the end of the skid formed an arch 70 in. long and 8 in. high at the highest point. Plate 13 shows this buckle as it appears from behind the load cart. It also shows the skid marks behind the tires. The mat was not deformed or broken, and settled back very nearly to its original position after the testing device was removed. Considerable rubber

was worn off the tires and left on the mat as the tires were dragged forward (plate 14).

23. <u>M6 mat -- not bedded</u>. This test was run with the tires skidding against the overlapping edges of the M6 mat which presumably is the most severe direction both with regard to tire wear and stresses imposed upon the mat. During the skid, which extended about 30 ft, the M6 hi-speed tractor was able to tow the runway load testing device with comparative ease, indicating much less resistance than on the M7 mat. In this test, the right tire skidded the entire distance but the left tire skidded only little more than 50 per cent of the total distance traveled after the brakes were set. The fact that both wheels were not skidding caused part of the difference in the resistance on the two mats, but it is believed that the primary reason for the difference was the fact that the surface of the M7 mat offered more resistance than the M6 mat. It is probable that the wheel that skidded only part time exerted more moving force on the mat than the wheel that skidded all the way. This is indicated by the fact that rubber worn from the tire that failed to skid was left in the track for the full length of the test, whereas rubber was not worn off the other tire along the full length of the track. Results obtained from this test were quite similar to those obtained from the test on the M7 mat. The mat moved only 1/4 in. at the anchor point. It started buckling after the tires had been pulled about 15 ft, and after the tires had traveled 24 ft the buckle was almost exactly like the final buckle on the M7 mat. At the end of the test, however, the buckle was in the form of a double arch, with one peak 3 in. high and the other 6-3/4 in. high. Its over-all length was 11 ft. Plate 15 shows the mat buckled

ahead of the wheels at the end of the test. This view is from behind the load cart. The left tire mark shows how the wheel alternated between rolling and skidding through part of the test. Plate 16 shows that the amount of rubber left on this mat was nearly the same as that left on the M7 mat. The tires had changed very little in appearance from the condition at the end of the test on the M7 mat.

24. M7 mat -- bedded. After traffic tests with the 50,000-lb single wheel load had been run on lane 2 and the mats were thoroughly embedded in the subgrade, a second set of braking tests was run with the 70,000-lb dual wheel load. One pull was made over the M7 mat with both wheels between end joints and another with one wheel skidding over a line of end joints. There was very little difference between the amount of rubber lost while skidding between joints and that lost while skidding on the end joints. Plate 17, figure 1, shows the rubber lost at a joint. This photograph should be compared with plate 14. On the first pull (both tires moving between end joints) the wheels were skidded a distance of 18 ft. The power required to skid the load cart wheels over the bedded mat appeared to be slightly less than was required on the new mat, but the bedding had very little effect on mat movement or buckling. The anchored end of the mat moved forward 3/8 in. and the mat started buckling after the tires had skidded about 3 ft. At the end of the skid there was a buckle ahead of the wheels 60 in. long and 5-1/4 in. high at its mid-point. On the second pull one wheel skidded directly over a line of end joints for a distance of 21 ft. The bedding had been broken during the first pull so that in effect the mat was not embedded in the subgrade during this phase of the test. Total movement (for both pulls)

of the anchored end of the mat was 3/4 in. at the end of the test. The mat was buckled ahead of the wheels into an arch 75 in. long and 11 in. high at the mid-point. During both of these pulls, the M6 hi-speed tractor was just barely able to tow the load cart without help from the prime mover.

25. M6 mat -- bedded. This test was conducted on the M6 mat completely bedded in the subgrade. The hi-speed tractor was able to tow the load cart through a 29-ft skid without difficulty. There was no movement at the anchored end of the mat. Buckling ahead of the wheel did not start until the wheels had skidded 19 ft. At the end of the skid there was only a slight buckle about 53 in. long and 2 in. high. This indicates that bedding was more effective in preventing movement of the M6 mat than it was in the case of the M7 mat. Tire wear was less than on the previous tests over M6 mat before it was bedded; however, two comparatively large chunks of rubber, one of which is shown on plate 17, figure 2, were torn from the edges of the treads. It is possible that this rubber had been loosened during previous tests.

Traffic tests -- 50,000-lb single wheel load

26. For the tests with a 50,000-lb single wheel load, the load cart was fitted with a single wheel, carrying a 56- by 16-in. 20-ply rating nylon airplane tire. This tire was inflated to 200 psi and while its rolling radius was not measured, it coincided very nearly with the deflection line as placed on the tire by the manufacture. Plate 18 is a print of this tire loaded and inflated as described above.

27. M7 mat in subsection 3a. The arrangement of mats in the different lanes and sections is shown on plate 7. The M7 mat with double

end connectors in subsection 3a was laid in a normal manner, except that only half of the locking lugs (alternate lugs) were bent down into locking position. The purpose of this arrangement was to determine whether any of the locking lugs could be omitted without reducing the efficiency of the mat. The 50,000-lb load on a single 56- by 16-in. tire inflated to 200 psi imposed a very severe test on the mats. The mat in this subsection deflected noticeably under the load from the beginning of the test, but did not start bedding into the subgrade until about the twelfth coverage. At 40 coverages the apparent mat movement had decreased noticeably and the mat was beginning to bed in the subgrade. At 220 coverages the mat was fairly well embedded. There was evidence of consolidation in the subgrade in that the general surface of the mat in the traffic lane had been depressed about 1 in. However, there was no apparent soil movement under the wheel and no mat breakage had occurred. The only sign of mat deformation was a slight opening up on the end joints. At 270 coverages the end connector bayonets were beginning to spread open at the points, allowing some unevenness at the end joints and the narrow bands of metal carrying the locking lugs were beginning to show signs of excessive strain. The section as a whole, however, remained smooth. Three of these narrow bands had broken at lugs opposite end joints at 280 coverages. At 338 coverages these bands started breaking at lugs not adjacent to end joints. This breakage continued to develop slowly until at the end of the test (966 coverages) there were 23 breaks opposite end joints and 22 breaks at points between end joints. The test was stopped at 966 coverages due to failure of the tire. Plate 19 shows the tire failure. Both the subgrade and mat surface remained in

excellent condition and the breaks apparently had no detrimental effect on the carrying capacity of the mat under the test conditions. The breaks probably resulted from fatigue induced by continued deflection under the wheel load but the mat still retained ample strength to carry traffic on this subgrade. A view of subsection 3a, with subsection 3b in the background, before traffic testing is shown in plate 6. Plate 20 shows detail of a double end connector joint and the method of engaging alternate locking lugs. Plates 21 and 22 show subsection 3a after 280 and 966 coverages, respectively. Plate 23, figure 1, is a photograph of a typical break in the narrow band carrying the locking lug. At the end of the test the mat surface had been depressed about 1.3 in. This depression was due partly to the mat embedded in the subgrade and partly to compaction of the subgrade under traffic. Soil measurement made after the test indicated that CBR values had increased under traffic by about 100 per cent at the surface and about 20 per cent at 1 ft below the surface, but had remained practically unchanged at 2 ft below the surface.

28. M7 mat in subsection 3b. In this subsection all locking lugs were bent down into locking position, otherwise it was similar to subsection 3a. There was an area in the northeast quarter of the subsection where mat deflection was more pronounced and the subgrade depression was greater under traffic than the average for subsections 3a and 3b. This was considered to be due to a small area of low density soil in the subgrade which was not found in the before-traffic soil measurements. This area consolidated under traffic to about the same degree of strength and density as the subsection as a whole. Mat breakage started in the area at about 260 coverages, which was 10 coverages earlier than in subsection

3a, and progressed more rapidly than it did in subsection 3a. In addition to the breaks at locking lugs, the end connector bayonets of the underlapping planks started breaking as shown on plate 23, figure 2. Only a few of these bayonets broke completely off, but since they all cracked and spread open as the mat started deflecting under traffic, they were not effective in maintaining smoothness at the joints. While the mat as a whole remained comparatively smooth and usable throughout the test, the overlapping planks curled up slightly and formed open joints at 280 coverages that apparently could have caused excessive tire wear. This condition and the general appearance of the section at this stage of the test are shown on plate 24. Except for an increase in mat breakage, there was little change in the condition of either subgrade or mat from 280 coverages to the end of the test at 966 coverages (plate 25). The breaks in subsection 3b at 280 and 966 coverages were as follows:

Type of Break	280 Coverages	966 Coverages
End bayonets	10	40
At lugs opposite end joints	10	28
At lugs away from end joints	17	70
In band on edge of plank not carrying locking lugs	2	8
Bayonets	0	1
Edge of plank to tubulated hole	0	1
	39	148

29. The number of locking lugs engaged (all lugs or half of the lugs) had no effect on the behavior of the mat in these tests. There was no evidence of serious stress in any of the lugs at any time. In fact, many of them never came in contact with the bayonets they were intended to bear against. It was noted that, after the mat had been subjected

to test traffic, the horizontal bayonets were jammed into the slots so that the square shoulders at the bayonet bases would prevent separation of the mats even if the locking lugs were not engaged. This feature is depicted on plate 26, and while it makes the intentional removal of the mat much more difficult, it might also make its ultimate destruction in service less likely.

30. M6 mat in section 4. The M6 mat was included in these tests to serve as a standard with which to compare the behavior of the new M7 mat. Subgrade conditions in section 4 were comparable to those described for subsections 3a and 3b. Plate 27 shows the mat before test. This mat, having fewer and thinner ribs than the M7 mat, bedded into the subgrade much more readily. The embedding process started with the first few coverages and was 25 per cent complete at 12 coverages. The subgrade consolidated slightly faster than it did in the M7 mat sections, but ultimately received about the same degree of increase in density and strength. The mat bent readily under the wheel load so that it conformed closely to the contour of the subgrade at all times after the first few coverages. There was considerable apparent mat movement during the period of subgrade consolidation, but this became less as the compaction under traffic progressed and was barely noticeable at 92 coverages except in a small area at the north end of the section (station 0+90 to 1+00). Some roughness started developing early in this area, and continued to develop throughout the test, probably due in part to nonuniform compaction at the end of the lane and in part to roughness that developed in the nonprocessed area outside of the lane progressing into the processed lane. At 280 coverages a few mat breaks started occurring in this portion

of the lane, but none had occurred back of station 0+90. At 450 coverages the roughness mentioned above had progressed back into the lane to station 0+75 and a few more breaks had occurred, bringing the total to 19. At this stage of the test the mat north of station 0+75 was bending under every pass of the wheel load, and the end connectors were being subjected to terrific punishment but none of them had broken or allowed the end joints to open up. The area between 0+50 and 0+75 was still in good condition with few, if any, mat breaks. From 450 coverages to the end of the test at 966 coverages the roughness of the entire section increased very slowly, but the decided roughness at the north end did not progress farther into the section; in fact, after about 500 coverages the subgrade seemed to consolidate and get somewhat harder. Mat breakage increased at a comparatively uniform rate from this stage to the end of the test. Despite the great amount of bending to which the mat was subjected, however, all end connectors held and all end joints were in good condition throughout the test. The total breakage in section 4 is listed below:

Bands outside bayonet slots, opposite end joints	32
Bands outside bayonet slots, between end joints	16
Breaks from edge of plank to first line of tubulated holes	63
Breaks from one tubulated hole to another	3

Plates 28 and 29 illustrate the appearance of the section after 280 and 966 coverages, respectively.

Traffic tests -- 70,000-lb dual wheel load

31. For the tests with the 70,000-lb dual wheel load the test load cart was equipped with 56-in. dual airplane wheels and tires. The tires were inflated to give a loaded rolling radius of 23.33 in. This required an inflation pressure of about 85 psi.

32. M7 and M6 mats in lane 1. As a result of the very slow bedding rate observed in the test on lane 2 it was decided to leave a thin layer of lightly compacted material or bedding mulch at the surface in test lane 1. This was accomplished by leaving about an inch of loose material on the section. Both types of mat bedded into the subgrade much faster and more satisfactorily than they had in the subgrade of lane 2. The M6 mat was completely bedded down at 16 coverages, and except for the small area containing the PBS blanket referred to in paragraph 12, the M7 mat was fairly well bedded at 90 coverages. After the mat was completely embedded in the subgrade, there was little change in the appearance or condition of the lane throughout the tests. The general surface of the traffic lane had been depressed from 1 in. to 1-1/4 in. at 90 coverages, and this had increased by about 1/4 in. at 1000 coverages. No mat breakage occurred during the test. The subgrade consolidated to the extent that CBR values increased from about 16 to 48 at 2 in. below the surface, 16 to 30 at 9 in. below the surface, and 12 to 20 at 15 in. below the surface. There was no appreciable change below this depth. Plate 30 shows the mats before testing and plates 31 and 32 show the M7 and M6 mats, respectively, after testing. It was noticeable that the 70,000-lb dual wheel load did not impose as severe a test on the mats as the 50,000-lb load on a single wheel used on lane 2.

33. Effect of M7 mat on PBS. The M7 mat is designed so that no bayonets or sharp edges come in contact with the surface on which it is laid. In order to test the efficiency of PBS as a dustproofing and waterproofing material when used under M7 mat, a PBS blanket about 10 ft wide by 12 ft long was placed under the mat in subsection 1a of traffic

lane 1 and its behavior was observed during the traffic test. This blanket was made of used PBS and was not in very good condition. It was observed that the M7 mat bedded into the subgrade more slowly over the PBS than it did in the remainder of the section. As the ribs of the M7 mat were forced into the subgrade, the fabric of the PBS blanket was stretched so tightly that a few breaks occurred, but it is possible that these were at points weakened by previous use. It is also probable that the stretching would have been more severe if a large area of PBS had been placed under the mat. Very few actual cuts were found in the blanket, though a few holes did appear under end joints. Plate 33 shows a section of the blanket when the mat was removed after 1000 coverages. The PBS was cut and punctured much less than in previous tests where PBS was placed under M6 and other types of landing mats. It would not have allowed much dust to be picked up by the backwash from propellers, and might have reduced the quantity of moisture percolating into the subgrade. It is believed that the blanket would have been subjected to more severe punishment on a soft subgrade because of the greater amount of movement.

34. M7 mat in subsections 5a and 5b. Lane 3, which included subsections 5a, 5b, and section 6, was built with a weak subgrade calculated to induce early mat breakage for better comparisons of the relative merits of the two mats and the benefits derived from the two methods of engaging the locking lugs on the M7 mat. However, the number of locking lugs engaged had no effect on results obtained from these tests since few, if any, of them were actually stressed and none of them was broken under traffic. Hence, while all lugs were engaged in subsection 5b and

only half were engaged in subsection 5a, the behavior of the mat in both subsections will be described in this paragraph without regard to locking lugs. The subgrade was just slightly weaker in subsection 5b than in 5a. Consequently mat movement and deflection were slightly greater in 5b, with the result that mat breakage started a few coverages earlier and may have progressed a little faster. Otherwise there was no difference between results from the two subsections. The mat was completely embedded in the subgrade during the first 10 coverages. The planks deflected noticeably under each pass of the test load but except for some curling up at the ends did not retain much permanent set during the first 50 coverages (plate 34). The permanent set was considerable after 182 coverages as can be seen in plate 35. The first breaks occurred between 10 and 20 coverages in the bands carrying locking lugs opposite end joints (see plate 20 for location of this band). The next breaks occurred in the same positions with respect to the locking lugs but between end joints. These were followed by breaks opposite end joints in the bands of metal outside the bayonet slots on the side of the planks not equipped with locking lugs (location also indicated on plate 20). At 50 coverages these breaks totaled 40, 115, and 13, in the order named above. At 114 coverages the planks had started to retain considerable permanent set, especially in subsection 5b, and had started breaking through to the first line of tubulated holes at points opposite end joints (plate 36). The severe flexing and permanent set had caused the deep ribs to start flaring open at the tops and thus increase the over-all widths of the planks. This increase in plank width had subjected the shanks back of the inclined bayonets to very high stresses

and some of them were beginning to shear off (plates 36 and 37). None of the end connector bayonets had broken but they were beginning to spread and allow considerable opening up of the end joints. Despite all this breakage the mat still retained enough stiffness and continuity to maintain a comparatively smooth usable surface without serious tire hazards. At 182 coverages the tractor of the testing device had a breakdown which would have required several hours to repair. Since this delay would have permitted the subgrade to harden somewhat, and since sufficient comparative data had been collected, the test was stopped. At this time, there was a break in the metal band at every locking lug in the traffic lane; the band on the side of the plank not equipped with locking lugs was broken at every end joint but three and was cracked at many places between end joints. There were 101 breaks from edge of plank to tubulated hole, and 129 shanks behind inclined bayonets were sheared off. None of the end connector bayonets were broken off, but all of them were so badly spread open that they had ceased to be effective in holding the end joints closed. However, at the end of the test, with the mat broken up as described above, the surface was not excessively rough, there were no serious tire hazards and the mat still afforded considerable protection to the subgrade. While its efficacy as a landing surface for heavy planes was becoming questionable, it had actually sustained traffic of the 70,000-lb dual wheel load on tires with 85 psi inflation to about 1/6 of 1000 coverages. Assuming that the fraction of 1000 coverages sustained is equivalent to a corresponding fraction of a year's service, as discussed in paragraph 15, this would indicate that M7 mat on this type of subgrade might be expected to sustain traffic of

military aircraft of similar wheel loads and tire pressures for about 2 months of normal operations on field airdromes in the theater of operations. The subgrade was tested during the period of traffic for changes in strength and cross sections were taken to determine if lateral flow of the subgrade occurred, but neither changes in strength nor lateral flow occurred to any appreciable extent. Before testing, the sections in lane 3 had the same appearance as those in lane 1 shown on plate 30. It should be remembered that this same mat had received 1000 coverages of the 70,000-lb dual wheel load while on lane 1 prior to being placed in lane 3. Plates 34 and 35 show the condition of subsection 5b after 50 and 182 coverages, respectively. Subsection 5a presented a slightly better appearance than subsection 5b throughout the test. Plate 36 shows how the end connector bayonets spread allowing the joints to open up and how the plank width increased causing the bayonet shanks to shear off. The width of some of the planks increased as much as 1 in. Plate 37 shows typical mat breakage which occurred on the line between subsections 5a and 5b at 182 coverages.

35. <u>M6 mat in section 6</u>. The subgrade in section 6 was slightly stronger than that in subsection 5b and practically the same as that in subsection 5a (see tabulation in paragraph 13). The mat was embedded in the subgrade with the first two coverages. At 10 coverages some subgrade material was working up onto the mat through the tubulated holes, and the mat was bending so as to leave shallow ruts behind the test wheels with each pass of the load cart. The mat did not spring back to a smooth contour after the machine passed but stayed bent to the surface of the subgrade at all times. At 20 coverages these ruts behind the wheels averaged about 1-1/2 in. below the general surface of the traffic lane. At

50 coverages the subgrade was beginning to flow laterally to the extent that noticeable ridges were forming along each side of the traffic lane. While no mat breakage had occurred, the surface of the lane had become so rough and the subgrade was moving under traffic to such an extent at about 60 to 80 coverages that the operation of a 70,000-lb dual wheel load at landing speeds might have been hazardous. The yielding mat and subgrade had caused the rolling resistance to increase to such extent that it was questionable as to whether or not a heavy airplane could attain sufficient speed for a take-off. Translating coverages into length of service under airplane traffic as described in paragraph 15, this would indicate a rather precarious service life in the theater of operations of about 1/2 month for the M6 mat on a subgrade having a minimum in-place CBR of 9 per cent. The first mat breakage, consisting of 3 breaks in bands outside the bayonet slots opposite end joints and 2 breaks from edge of plank to tubulated holes, was found at 114 coverages. Surface conditions continued to grow worse and mat breakage increased until the end of the test at 182 coverages, when the total breakage consisted of 37 breaks in the bands outside the bayonet slots opposite end joints, 42 breaks from edge of planks to tubulated holes, and 4 end locking pieces pulled out. While the end locking pieces were subjected to terrific punishment during the test, they proved very tenacious and maintained smooth continuity of end joints at all times. The wheels were leaving ruts as much as 6 in. below the original mat surface, and the lateral movement of subgrade material had created ridges 3 to 4 in. high along the edges of the traffic lane. From these conditions it is evident that while the M6 mat held together longer and was much more resistant to breakage than the M7, it did

not protect the subgrade to the extent that the M7 mat did. Plates 38, 39, and 40 show the mat after 20, 114, and 182 coverages, respectively. In plate 40 the mat has been swept for final inspection and photographing. Plates 41 and 42 show the comparative roughness of the M6 mat and the M7 mat at the end of the test.

Deflection measurements

36. The deflection of the two types of mat under the 50,000-lb wheel load was measured in test lane 2 after the mat was embedded in the subgrade. These measurements were made by taking level readings with a special scale to hundredths of inches at 6-in. intervals on the mat without a wheel load and then repeating these readings with the wheel load standing on the line of measurements. Similar deflection measurements were made on the two types of mat under the 70,000-lb dual wheel load in test lane 1 both before any traffic had been applied and after the mat was embedded in the subgrade. When using the 50,000-lb single wheel load with approximately 6 ft 4 in. of space between the test wheel and the outrigger wheel, the deflection was downward at the test wheel and for a distance of about 15 in. on either side from the test wheel. Then it was upward for some distance and downward again near the outrigger wheel. When using the 70,000-lb dual wheel load with only 4 ft 7 in. between test wheels and outrigger wheels all of the deflection was downward in three of four sets of measurements. The results of these measurements are tabulated below. Since this report is concerned primarily with deflections caused by the test wheel load, only downward movements of the mat out to the point of minimum deflection are listed. Distances are measured from point where the edge of the tire touches the mat. All

measurements are in inches.

Deflection of M7 mat, bedded, under 50,000-lb single wheel load.

Distance from tire	0	6	12	15
Downward deflection	.32	.27	.10	0

Deflection of M6 mat, bedded, under 50,000-lb single wheel load.

Distance from tire	0	6	12	15
Downward deflection	.38	.27	.08	0

Deflection of M7 mat, not bedded, under 70,000-lb dual wheel load.

Distance from tire	0	6	12	18	21
Downward deflection	.20	.17	.11	.08	.05

Deflection of M7 mat, bedded, under 70,000-lb dual wheel load.

Distance from tire	0	6	12	18	23
Downward deflection	.18	.12	.08	.05	.04

Deflection of M6 mat, not bedded, under 70,000-lb dual wheel load.

Distance from tire	0	6	12	18	21
Downward deflection	.42	.25	.14	.03	0

Deflection of M6 mat, bedded, under 70,000-lb dual wheel load.

Distance from tire	0	6	12	18	24
Downward deflection	.25	.19	.07	.05	.03

37. It is noted from the data above that the deflection was consistently less for any one load or mat where the mat was bedded than where it was not bedded, which is as expected. By comparison of the values where the mat was bedded in the subgrade, information on the

effectiveness of the two types of mats can be obtained. It is noted that, for the bedded condition, the M6 mat showed about 20 per cent greater deflection at the edge of the 50,000-lb tire than the M7 mat and about 40 per cent greater deflection at the edge of the tire on the 70,000-lb dual wheel load than the M7 mat. Under the 50,000-lb single load the deflection reached a value of zero at 15 in. from the tire under both types of mat. Under the 70,000-lb dual wheel load the deflection approached a value of zero at 21 in. to 24 in. from the tire. The spread for this condition may have been effected by the outrigger wheel.

Tire wear tests

38. Surfaces included in tests. Three typical surfaces were used in the tire wear tests. These were: (a) M6 landing mat bedded into the subgrade by traffic; (b) M7 landing mat bedded into the subgrade by traffic; and (c) asphalt concrete pavement, well cured and scoured clean by traffic. The load cart was towed over the M6 mat against the overlapping edges of the planks and across the end joints at various angles. It was towed over the M7 mat both between end joints and across end joints at various angles. The two landing mat surfaces are shown in the traffic test plates, especially plates 31 and 32. The asphaltic concrete pavement was a previously-used test site. Plate 43 shows the typical texture of that portion of the lane used in these tests; the dark portion on the right is where the tire was skidded.

39. Braking resistance. The brake system on the airplane wheels used in these tests consisted of a smooth metal disk keyed to the wheel and placed between three sets of fiber plates. These fiber plates were actuated by hydraulic pressure which imposed friction on the smooth

metal disk and tended to prevent rotation of the wheel. Consequently the amount of hydraulic pressure required to just lock the wheel served as an index to the braking resistance or friction between the tire and the surface under consideration as the wheel was towed over that surface without rotation. The hydraulic pressure to operate the brakes was supplied by a high-pressure pump equipped with an accurate pressure gage. While braking resistance on the three surfaces under consideration was not a primary feature of the tests, the average pressures required to just lock the wheel were obtained and recorded. The average pressure required to lock the wheel was 1700 psi on the M6 landing mat, 1900 psi on the M7 landing mat, and 2150 psi on the asphaltic concrete. Since the pressure required to lock the wheels was proportional to the resistance offered to the tire, it is seen that the asphaltic concrete was the best surface from the standpoint of stopping a plane, the M7 mat the next best, and the M6 mat the poorest.

40. Tire wear. The following tabulation shows the amount of rubber lost in the tire wear tests on the three different surfaces.

Surface	Tire	Original Weight (lb)	Final Weight (lb)	Loss (lb)
M6 mat	Firestone 11-472432	26.92	26.43	0.49
M7 mat	Firestone 12-470885	28.29	26.84	1.45
Pavement	Firestone 12-471369	27.99	26.40	1.59

Plates 44 and 45 show the appearance of the tires before and after the test, together with small sections of the surfaces on which they were tested. It is noted that the amount of rubber lost was greatest for the asphaltic concrete, next for the M7 mat, and least for the M6 mat. The amount lost on the M7 mat was 91 per cent of that lost on the pavement,

and the amount lost on the M6 mat was 31 per cent of that lost on the pavement. It should be noted that the amount of rubber lost was proportional to the resistance to skidding offered by the three surfaces.

41. Efficacy of braking equipment. While not included in the scheduled tests, notes were kept on the efficacy of the braking equipment used in these tests. These brakes probably are entirely adequate for normal use of airplanes, but both the load imposed on the wheel and the method of using in these tests were more severe than would be expected in normal operation. The pressures required to lock the wheels on the three surfaces used in the tests are listed in paragraph 39. For satisfactory operation, pressures about 100 psi above those were used. It was found that one brake assembly broke after 23 applications of the brake at about 2,000 psi and 20 applications at 1,800 psi. Another broke after 17 applications at 2,000 psi, and a third broke on the second application at 2,300 psi. Plate 46, figure 1, shows these broken parts. When the third break occurred it was evident that the wheels could not be locked in this manner a sufficient number of times to complete the test on the asphaltic concrete pavement. Consequently the smooth hard metal disk was replaced with one made of soft iron and drilled to receive a pin that would lock the wheel in 12 different positions. Plate 46, figure 2, shows this disk and locking pin in place on the assembly.

Pressure distribution tests

42. Plates 47 through 50 show plots of the major and minor principal stresses, the vertical and horizontal pressures and the deflections.

The four plates show plots for 15,000-, 30,000-, 45,000-, and 60,000-lb loads. The measured values and the values computed from measurements are plotted as test points. In addition, a curve is drawn on each plot showing the theoretical value. This theoretical curve is based on an elastic, isotropic, homogeneous material. In order to compute a theoretical curve for deflections it was necessary to have a value for the modulus of elasticity. Since no methods are available for determining a modulus of elasticity for soil, theoretical curves are shown for values of 20,000 and 50,000 lb/sq in./in. which bracket the measured test values. In considering the data shown on the plots it should be borne in mind that these data represent values at a depth of 12 in. in the subgrade.

43. An inspection of the plots gives an idea of the relative merits of the landing mats in distributing stress at the 12-in. depth. It can be seen that in practically all cases the stress at the 12-in. depth shows only a small difference for the condition of no mat, M6 mat, or M7 mat. For the lower loads, the trend is not very consistent, but for the higher loads the condition of no mat resulted in the higher stresses, M6 mat the next, and M7 mat the least. The deflection measurements, which are considered more reliable than the stress measurements since deflections are easier to measure than stresses, show this same trend. Under the center (at zero offset) of a 60,000-lb load (plate 50) the deflections were 0.110, 0.094, and 0.088 in. for no mat, M6 mat, and M7 mat, respectively. In general, the vertical pressure and the minor principal stresses reached a value of practically zero at an offset of about 3 ft, but the horizontal pressures, the major principal stresses, and the deflections showed measurable quantities out to about 5 to 6 ft.

The measured stresses generally agree with the theoretical curves. The theoretical deflection curves based on a constant modulus of elasticity do not agree with the measured data.

44. The results of these tests show that the beneficial effects of the landing mat in protecting a subgrade at a depth of 12 in. are very small. The beneficial effects in the upper 12 in. may be appreciable. It should be noted, also, that the deflection was only about 0.1 in. under the test conditions. In this connection, the results of deflection tests shown in plate 3 indicate that the mats may have shown more benefit on a weak subgrade where the deflection would have been higher.

Rolling resistance tests

45. The results of the rolling resistance tests are tabulated in table 2. The table shows the load required to start the cart moving and the load required to keep it running on both types of surface. Values are also shown for the tare, which is the load required to tow the prime mover and the yoke alone. Individual test values are shown in each case. Average values are also shown together with the value less the tare, which is the load required for the 70,000-lb dual wheels alone.

46. In general, the individual values for the load required to start the cart tended to be erratic. This was caused by the differences in rates of acceleration in the first few feet of movement. No method was available to maintain a constant rate of acceleration, nor was the rate of acceleration measured. In general, approximately 25 to 35 seconds were required to start the cart, bring it to a speed of approximately 4 mph, and tow it across the lane. The total distance traveled

was 35 to 45 ft.

47. The temperature of the oil and grease in the prime mover and the load wheels was a definite factor in the first series of tests. These were conducted on the 20-25 CBR subgrade at 90, 120, 110, and 100 lb tire pressure, in the order named. The air temperature was relatively low (near freezing) and the tests were started without a preliminary, warm-up period. An inspection of the results at the end of the first day's testing showed that the rolling resistance decreased in order of testing. In the next day's testing it was found that after about a 30-minute warm-up period the added resistance due to the high viscosity of the cold lubricants was eliminated. In all subsequent tests the unit was warmed up prior to testing. The data from the first series of tests were used, but little weight was given to the first two runs which were made at 90 and 120 lb tire pressure.

48. Plate 51 is a plot of the rolling resistance of the 70,000-lb dual wheels alone (tare subtracted) against tire pressure. The load required to start the wheels moving is shown by circles, and the load required to keep the wheels running is shown by squares. The data for the subgrade are shown by open symbols and the data for the M7 mat are shown by solid symbols. Curves are shown for each of the four cases. The tests made on the subgrade at 90 and 120 lb tire pressure in the first series, where the results were influenced by the cold lubrication, were given very little weight. A study of the curves indicates that the load required to keep the wheels running does not vary with the tire pressure. The load required on the mat is about half the load required on the subgrade. The load required to start the wheels moving seems to

show some influence of tire pressure with the greater load being required for the higher pressures. The load required to start the wheels moving on the mat was greater than on the subgrade, which is the reverse of the case for the load required to keep the wheels running. It is entirely possible that the differences in the loads required on the mat and on the subgrade in both cases may be due to difference in rates of acceleration. It was noted that a rapid rate of acceleration gave a relatively high pull required to start the wheels moving, which was followed by a relatively low pull required to keep the wheels running. Due to the possibility of differences in the rates of acceleration, it is doubted if the trends indicated on the plate are entirely valid. It is believed that the data should be analyzed as indicating that, for the conditions of the tests, a load ranging from 4,000 to 11,000 lb was measured in starting the wheels moving and a load ranging from 1,000 to 3,000 lb was measured during the period the wheels were running. It is considered that a more accurate solution to the problem would require equipment to maintain and measure a constant rate of acceleration in the first few feet of the tests; such equipment was not available at the Waterways Experiment Station.

Summary of Test Results

49. Below are summarized the pertinent results obtained from these tests:

a. Mat breakage and deformation under a 50,000-lb single wheel load with 200 psi tire inflation and on a subgrade with a CBR of 20 to 25 per cent at the start of traffic were considerable but not serious

in either the M6 or M7 mats. The mat breakage was greater on the M7 mat than on the M6 mat, but deformation was greater on the M6 mat.

b. Both M7 and M6 mats when placed on subgrade with CBR values of approximately 15 per cent at the start of traffic withstood 1000 coverages by a 70,000-lb dual wheel load, with 56-in. tires inflated to a rolling radius of 23.33 in., without suffering any visible damage.

c. Mat breakage at the connections occurred much earlier and faster in the M7 mat than in the M6 when both were laid on a subgrade having CBR values ranging from about 5 at the surface to about 10 at 14 in. below the surface and subjected to traffic by the 70,000-lb dual wheel load. However, even with the serious breakage of the connections in the M7 mat, it maintained a smoother traffic surface and offered more protection to the subgrade than the M6 mat.

d. The resistance to skidding of the 26-in. by 6.6-in. airplane tires was greatest on the asphaltic concrete, next on the M7 mat, and least on the M6 mat. The highest rubber loss occurred on the asphaltic concrete. The rubber loss on the M7 mat was about 90 per cent of that on the asphaltic concrete and the loss on the M6 mat was about 30 per cent of that on the asphaltic concrete pavement.

e. The deflection of the surface of the M6 mat at the edge of the tire was approximately 20 per cent and 40 per cent greater than the deflection of the surface of the M7 under the 50,000-lb single and the 70,000-lb dual wheels, respectively.

f. Under the 50,000-lb single wheel the surface deflection (of either mat) reached a value of zero at 15 in. from the edge of the

tire; under the 70,000-lb dual wheel the surface deflection approached zero at 21 in. to 24 in. from the edge of the tire.

g. The stresses and deflections induced at a depth of 12 in. in the subgrade with a CBR of 10 per cent were approximately the same for the condition of no mat, M6 mat, or M7 mat, with the M7 mat showing a slight advantage under the heavier loads.

Conclusions

50. The following conclusions have been drawn from observation of the tests and analysis of the data procured:

a. The soil bearing value of 15 CBR required for test sections in the plan of development for project 8-69-04-002 is too high and should be reduced to cover the range from 11 to 13 CBR.

b. Both M7 and M6 mats on a subgrade with a minimum in-place CBR of 15 per cent sustained satisfactorily 1000 coverages of a 70,000-lb dual wheel load on tires inflated to 85 psi and of a 50,000-lb dual wheel load on a tire inflated to 200 psi. This amount of traffic is considered approximately equivalent to one year of normal operation of planes with comparable wheel loads and tire inflation pressures on a field airdrome in a theater of operations.

c. M7 mat on a subgrade with a minimum in-place CBR of 9 per cent sustained satisfactorily 160 to 180 coverages of a 70,000-lb dual wheel load on tires inflated to 85 psi. This amount of traffic is considered approximately equivalent to 60 days' normal operation of planes with comparable wheel loads and tire inflation pressure on a field airdrome in a theater of operations.

d. M6 mat on a subgrade with a minimum in-place CBR of 9 per cent sustained satisfactorily 50 to 80 coverages of a 70,000-lb dual wheel load on tires inflated to 85 psi. This amount of traffic is considered approximately equivalent to 15 days' normal operation of planes with comparable wheel loads and tire inflation pressure on a field airdrome in a theater of operations.

e. 50,000-lb single wheel type landing gears with 200 psi tire inflation pressures are more destructive to landing mat surfaces than 70,000-lb dual wheel landing gears with tire inflation pressures approximating 85 psi.

f. M7 mat gives more protection to a subgrade than that afforded by M6 mat.

g. M7 mat will cause less damage to treatments for dustproofing and/or waterproofing subgrades than the M6.

h.. Both types of end connectors (single and double) used on the M7 mat were unsatisfactory.

i. The average weight of M7 mat in quantity production will be within the 6.25 lb per sq ft maximum called for in the Plan of Test.

j. The M7 mat can be placed at about 112 sq ft per man hour from bundles distributed along the edge of a runway.

k. When cutting and welding equipment is available, removal and replacement of a section of M7 mat from within a runway can be accomplished expeditiously. However, if possible, the design should be modified to allow removal without cutting the connectors.

l. Engaging half the lugs provided on the M7 mat will lock the connectors sufficiently for the first installation and leave unused

lugs for a future installation.

m. The M7 mat is well adapted to nesting into compact packages for shipment.

n. The M7 mat will provide a better braking surface for aircraft than that provided by standard PSP or M6 mat but not so good as that provided by bituminous concrete surfaces.

o. The force required to keep the 70,000-lb dual wheel B-29 landing gear rolling, does not vary with tire inflation pressure in the range from 70 to 120 psi.

p. The force required to keep the 70,000-lb dual wheel B-29 landing gear rolling at 4 mph on a 15 CBR subgrade is approximately double that required to keep it rolling at the same speed on M7 mat placed on a 15 CBR subgrade.

q. The subgrade used in the pressure distribution tests did not allow sufficient mat deflection to show conclusively the beneficial effects of landing mat in protecting a subgrade at a depth of 12 in.

TABLES

TABLE I

TEST READINGS AND COMPUTED VALUES

Pressure Distribution Under Landing Mats

Stresses in PSI

No Mat — Offset - Feet[2]

Load Pounds	Stress or Angle[1]	0	1	2	3	4	5	6	7
15,000	σ_z	11.9	(7.6)	2.3	0.0	0.9	0.0	0.0	0.0
	σ_y	1.8	(0.6)	0.0	0.0	0.0	0.0	0.0	0.0
	σ_x	3.0	3.3	2.8	1.1	0.9	0.9	0.0	1.8
	σ_v	7.4	7.7	3.7	0.0	0.9	0.0	0.0	0.0
	σ_u	10.4	3.8	0.9	0.0	0.0	0.0	0.9	0.0
	σ_1	13.3	8.5	3.9	0.6	1.4	0.5	0.5	0.9
	σ_2	3.1	2.7	1.0	0.0	0.0	0.0	0.0	0.0
	σ_3	1.8	0.6	0.0	0.0	0.0	0.0	0.0	0.0
	θ	187.5°	159.9°	130.2°	-	-	-	-	-
30,000	σ_z	26.7	(16.1)	3.8	0.0	0.0	0.0	0.0	0.0
	σ_y	7.0	(2.0)	0.0	0.0	0.0	0.0	0.0	0.0
	σ_x	7.1	6.5	6.7	1.8	0.0	1.9	0.0	0.0
	σ_v	16.7	18.6	7.4	1.2	1.8	0.0	0.0	0.0
	σ_u	19.1	8.7	0.0	0.0	0.0	0.0	0.9	0.0
	σ_1	27.6	19.4	9.1	1.8	0.9	1.0	0.5	-
	σ_2	7.3	5.6	0.0	0.0	0.0	0.0	0.0	-
	σ_3	7.0	2.0	0.0	0.0	0.0	0.0	0.0	-
	θ	182.9°	159.7°	127.2°	112.5°	-	-	-	-
45,000	σ_z	41.5	(27.8)	5.7	0.0	0.0	1.4	0.0	0.0
	σ_y	10.1	(6.0)	1.0	0.0	0.0	0.0	0.5	0.0
	σ_x	10.4	10.1	9.8	2.4	0.0	1.9	2.4	0.0
	σ_v	25.4	29.1	11.1	1.9	1.8	1.2	1.7	1.7
	σ_u	28.2	13.9	0.0	0.0	0.0	0.0	0.0	0.0
	σ_1	42.3	32.0	13.5	2.6	0.9	2.3	2.5	0.9
	σ_2	10.5	8.4	1.0	0.0	0.0	0.0	0.5	0.0
	σ_3	10.1	6.0	0.0	0.0	0.0	0.0	0.0	0.0
	θ	182.9°	161.0°	127.7°	112.5°	-	-	-	-
60,000	σ_z	56.1	(47.0)	7.6	0.0	0.0	0.0	0.0	0.0
	σ_y	13.8	(9.2)	1.4	0.0	0.0	0.0	0.0	0.0
	σ_x	15.1	12.4	14.4	3.7	0.0	1.9	1.8	0.0
	σ_v	32.5	39.2	15.1	1.9	1.8	1.8	1.7	0.8
	σ_u	36.6	19.7	0.9	0.0	0.0	0.0	0.0	0.0
	σ_1	55.5	49.5	18.3	3.4	0.9	2.2	2.1	0.4
	σ_2	14.6	9.7	1.4	0.0	0.0	0.0	0.0	0.0
	σ_3	13.8	9.2	0.7	0.0	0.0	0.0	0.0	0.0
	θ	183.0°	164.8°	125.6°	112.5°	-	-	-	-

M7 Mat — Offset - Feet[2]

Load Pounds	Stress or Angle[1]	0	1	2	3	4	5	6	7
15,000	σ_z	15.2	(10.0)	2.9	0.0	0.9	0.0	0.0	0.0
	σ_y	2.1	(1.0)	0.0	0.0	1.2	0.0	0.0	0.9
	σ_x	2.4	2.7	2.8	0.9	1.6	0.0	0.0	0.9
	σ_v	7.4	7.4	4.6	1.9	1.5	1.8	0.0	0.0
	σ_u	7.0	2.9	0.0	0.9	1.8	0.9	0.0	1.9
	σ_1	13.8	9.9	5.2	1.9	1.9	0.9	-	-
	σ_2	2.2	1.6	0.0	0.0	1.2	0.5	-	-
	σ_3	2.1	1.0	0.0	0.0	1.0	0.0	-	-
	θ	170.2°	161.4°	135.6°	100.0°	80.3°	-	-	-
30,000	σ_z	29.9	(20.5)	7.0	0.0	0.0	0.0	0.0	0.0
	σ_y	4.1	(2.2)	0.0	0.0	0.0	0.9	0.0	0.0
	σ_x	7.1	6.2	6.4	2.1	0.0	0.0	0.0	0.9
	σ_v	16.7	17.0	8.3	3.7	2.1	1.8	0.0	0.0
	σ_u	15.7	6.4	0.0	0.0	0.0	0.0	0.0	0.0
	σ_1	28.1	21.4	10.9	3.5	1.8	0.9	-	-
	σ_2	6.6	3.6	0.0	0.0	0.0	0.9	-	-
	σ_3	4.1	2.2	0.0	0.0	0.0	0.0	-	-
	θ	178.2°	159.8°	136.1°	112.5°	112.5°	-	-	-
45,000	σ_z	44.9	(32.0)	12.0	1.0	1.2	0.0	0.0	0.0
	σ_y	7.9	(5.2)	1.4	0.0	1.7	0.9	0.9	0.0
	σ_x	10.7	8.9	9.2	3.7	1.9	1.9	1.8	1.2
	σ_v	24.0	26.8	13.0	5.6	3.0	1.8	1.4	0.0
	σ_u	23.8	10.1	0.9	0.0	1.8	0.0	0.0	0.0
	σ_1	41.9	33.6	16.6	5.6	2.7	2.2	1.9	0.6
	σ_2	9.8	5.4	1.4	0.0	1.7	0.9	0.9	0.0
	σ_3	7.9	5.2	1.0	0.0	1.3	0.0	0.0	0.0
	θ	179.8°	160.3°	139.5°	119.9°	114.9°	-	-	-
60,000	σ_z	58.3	(45.0)	14.3	1.9	0.0	0.0	0.0	0.0
	σ_y	10.3	(6.9)	2.1	0.0	0.9	1.2	0.0	0.0
	σ_x	14.2	11.9	12.5	5.5	2.5	0.9	0.9	0.9
	σ_v	31.6	30.7	16.7	6.8	3.6	2.4	1.7	1.1
	σ_u	32.2	13.9	2.1	0.0	1.5	0.0	0.0	0.0
	σ_1	54.5	46.0	20.3	5.9	4.0	2.0	1.6	1.2
	σ_2	13.6	7.2	2.5	0.0	0.9	1.2	0.0	0.0
	σ_3	10.3	6.9	2.1	0.0	0.0	0.0	0.0	0.0
	θ	180.5°	161.4°	137.2°	122.2°	-	-	-	-

M6 Mat — Offset - Feet[2]

Load Pounds	Stress or Angle[1]	0	1	2	3	4	5	6	7
15,000	σ_z	12.7	(6.0)	2.2	0.0	0.0	0.0	0.0	0.0
	σ_y	1.0	(0.4)	0.0	0.0	1.9	0.0	0.0	0.0
	σ_x	1.8	2.7	2.8	1.5	1.9	0.0	0.0	0.0
	σ_v	7.4	8.7	3.7	1.2	1.8	0.0	0.0	0.0
	σ_u	7.5	3.5	0.0	0.0	1.8	0.0	0.0	0.0
	σ_1	12.9	8.2	4.4	1.6	2.8	-	-	-
	σ_2	1.8	2.3	0.0	0.0	1.9	-	-	-
	σ_3	1.0	0.4	0.0	0.0	0.0	-	-	-
	θ	180.2°	156.1°	131.5°	112.5°	90.0°	-	-	-
30,000	σ_z	26.7	(12.8)	3.8	0.0	0.0	0.0	0.0	0.0
	σ_y	4.1	(2.9)	1.0	0.0	0.0	0.0	0.0	0.0
	σ_x	5.6	5.3	5.5	2.5	1.9	0.0	0.0	0.0
	σ_v	14.9	18.6	8.7	1.9	1.8	0.0	0.0	0.0
	σ_u	17.1	7.0	0.0	0.0	1.5	0.0	0.0	0.0
	σ_1	26.7	17.7	9.1	2.7	2.6	-	-	-
	σ_2	5.4	4.1	1.0	0.0	0.0	-	-	-
	σ_3	4.1	2.9	0.0	0.0	0.0	-	-	-
	θ	182.6°	156.2°	129.9°	112.5°	92.9°	-	-	-
45,000	σ_z	42.5	(23.0)	7.6	1.3	1.7	1.7	1.1	0.0
	σ_y	6.2	(3.6)	0.0	0.0	0.0	0.0	0.0	0.0
	σ_x	10.7	8.9	9.2	4.6	3.2	1.6	1.5	1.5
	σ_v	22.7	27.1	13.0	3.7	2.4	1.8	1.1	0.8
	σ_u	24.7	11.6	0.0	0.0	0.9	0.0	0.0	0.0
	σ_1	40.3	28.2	14.9	5.2	3.2	2.6	1.9	1.4
	σ_2	10.0	7.2	0.0	0.0	0.9	0.0	0.0	0.0
	σ_3	6.2	3.6	0.0	0.0	0.0	0.0	0.0	0.0
	θ	181.9°	158.9°	132.1°	120.4°	118.4°	-	-	-
60,000	σ_z	55.5	(36.0)	9.5	1.6	0.0	0.0	0.0	0.0
	σ_y	10.3	(7.8)	1.4	0.0	0.0	0.0	0.0	0.0
	σ_x	14.2	11.8	12.8	6.1	3.2	0.9	0.0	0.0
	σ_v	30.6	37.0	10.8	4.9	3.3	1.8	1.4	1.4
	σ_u	34.1	16.2	1.8	0.0	1.5	0.9	0.0	0.0
	σ_1	53.9	41.4	15.1	6.8	4.1	1.9	0.7	0.7
	σ_2	13.3	9.1	2.3	0.0	0.0	0.0	0.0	0.0
	σ_3	10.3	7.8	1.4	0.0	0.0	0.0	0.0	0.0
	θ	182.9°	160.7°	129.5°	119.9°	100.4°	99.5°	-	-

Deflections in Inches

Load Pounds	Condition	Offset - Feet[2] 0	1	2	3	4	5	6	7	8	9
15,000	No Mat	.018	.015	.006	.002	.001	.001	.000	.000	.000	.000
	M6	.016	.016	.006	.003	.001	.001	.001	.000	.000	.000
	M7	.015	.014	.006	.003	.001	.001	.001	.000	.000	.000
	Theor[3]	.017	.014	.008	.005	.004	.003	.003	.002	.002	.002
	Theor[4]	.007	.006	.003	.002	.002	.001	.001	.001	.001	.001
30,000	No Mat	.041	.038	.012	.005	.002	.002	.001	.000	.000	.000
	M6	.041	.032	.013	.006	.003	.002	.000	.000	.001	.001
	M7	.039	.032	.014	.005	.003	.002	.001	.000	.000	.000
	Theor[3]	.034	.029	.017	.011	.008	.006	.005	.005	.004	.004
	Theor[4]	.013	.012	.007	.004	.003	.003	.002	.002	.002	.002
45,000	No Mat	.068	.059	.019	.008	.005	.003	.001	.001	.000	.001
	M6	.065	.052	.021	.009	.004	.004	.001	.000	.001	.001
	M7	.065	.052	.020	.009	.005	.003	.002	.001	.000	.000
	Theor[3]	.050	.043	.025	.016	.012	.010	.008	.007	.006	.006
	Theor[4]	.020	.017	.010	.006	.005	.004	.003	.003	.002	.002
60,000	No Mat	.110	.087	.027	.010	.006	.004	.002	.001	.001	.001
	M6	.094	.075	.030	.013	.006	.004	.002	.001	.001	.001
	M7	.088	.074	.031	.013	.006	.004	.002	.002	.001	.000
	Theor[3]	.067	.057	.033	.021	.016	.013	.010	.009	.008	.008
	Theor[4]	.027	.023	.013	.009	.005	.005	.004	.004	.003	.003

NOTES:

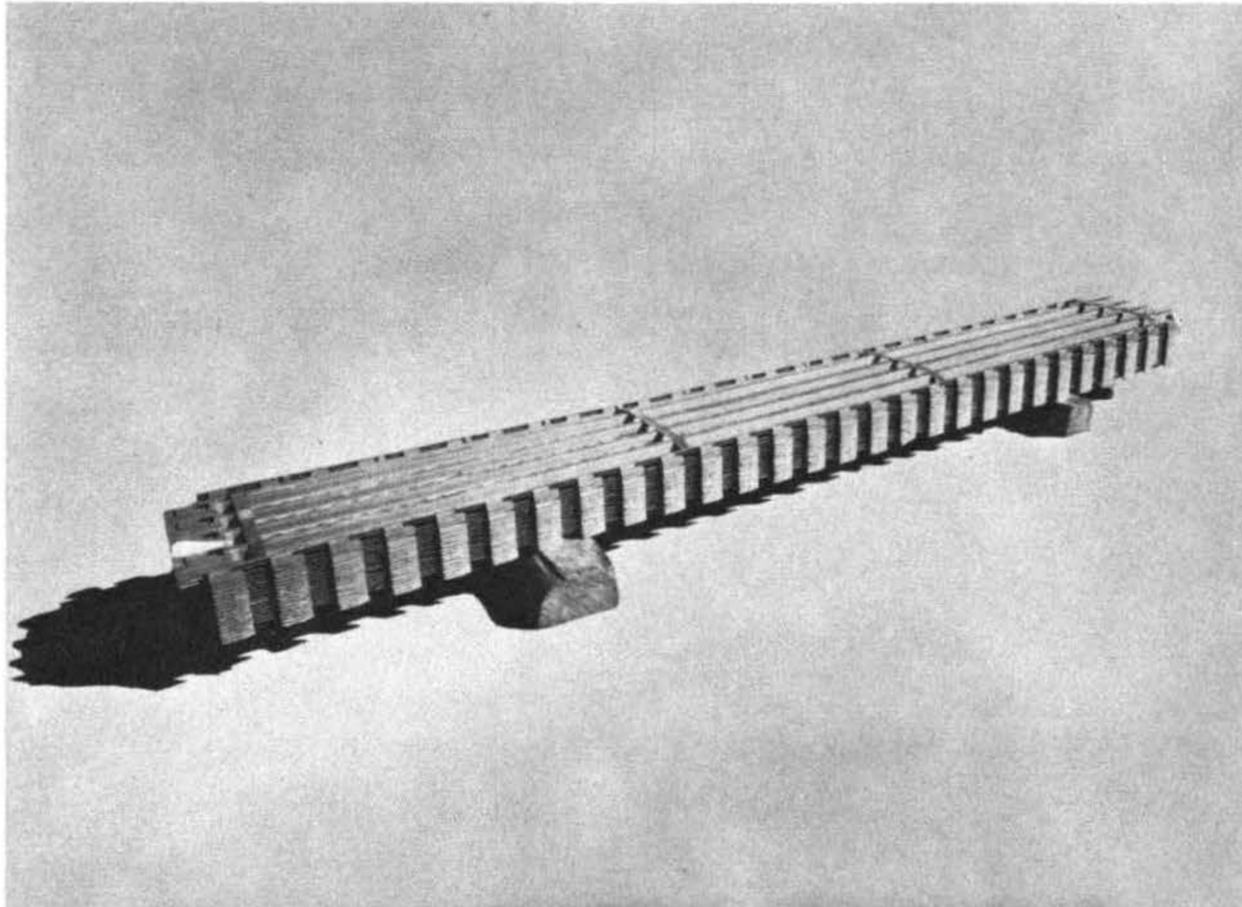
1. σ_z is vertical pressure, σ_x and σ_y are horizontal pressures on planes normal to each other, σ_v and σ_u are pressures on two different planes at 45° with the horizontal. σ_1 is the major, σ_2 is the intermediate, and σ_3 is the minor principal stress. θ is the angle between the major principal stress and the horizontal. σ_z, σ_x, σ_y, σ_u and σ_v are measured values except values in parentheses are interpolated. Values for σ_1, σ_2, σ_3, and θ are computed from the test results and are for the X axis.
2. Dash indicates no reading or value indeterminate.
3. With an assumed modulus of elasticity for the soil of 20,000 lbs/in^3.
4. With an assumed modulus of elasticity for the soil of 50,000 lbs/in^3.

TABLE II

ROLLING RESISTANCE TESTS

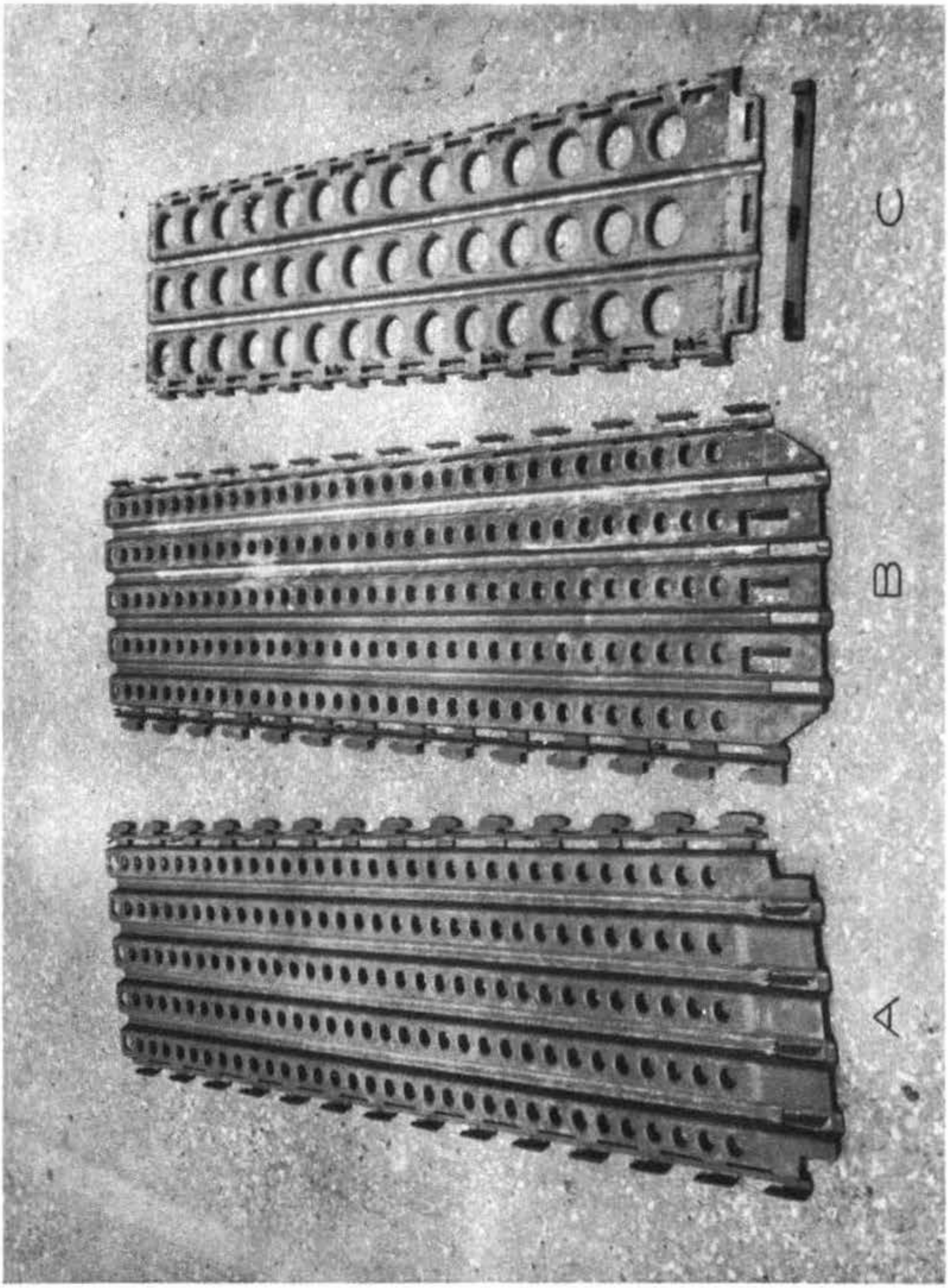
Test Conditions	Pass	Pull in Lbs With Load Tires at Indicated Pressure 120	110	100	90	80	70	Tare
On Subgrade, To Start Cart Moving	1	9,410	10,250	9,800	-	8,560	6,600	2,600
	2	7,980	7,500	7,000	11,280	9,400	6,750	3,100
	3	9,860	6,850	6,850	11,530	6,020	6,980	3,530
Avg.		9,080	8,200	7,880	11,400	7,990	6,780	3,080
Less tare		6,000	5,120	4,800	8,320	4,910	3,700	-
On Subgrade, To Keep Cart Running	1	3,670	3,380	3,090	4,340	3,880	3,880	878
	2	3,130	2,610	2,640	4,350	4,135	3,260	878
	3	4,100	2,570	2,550	4,120	3,000	3,110	1,125
Avg.		3,630	2,850	2,760	4,270	3,670	3,420	960
Less tare		2,670	1,890	1,800	3,310	2,710	2,460	-
On M7 Mat, To Start Cart Moving	1	13,600	11,900	10,200	8,400	9,950	8,600	3,070
	2	13,500	13,000	8,600	8,900	9,300	11,700	3,120
	3	13,800	11,600	10,000	9,800	11,750	11,900	3,220
	4	-	-	-	-	-	-	2,760
	5	-	-	-	-	-	-	2,760
Avg.		13,630	12,170	9,600	9,030	10,330	10,730	2,990
Less tare		10,640	9,180	6,610	6,040	7,340	7,740	-
On M7 Mat, To Keep Cart Running	1	2,220	2,200	2,260	2,340	2,190	2,180	1,200
	2	2,540	2,340	2,180	2,330	2,400	2,110	1,245
	3	2,330	2,030	2,190	2,240	2,170	2,270	1,140
	4	-	-	-	-	-	-	1,075
	5	-	-	-	-	-	-	1,162
		2,360	2,190	2,210	2,300	2,250	2,190	1,160
		1,200	1,030	1,050	1,140	1,090	1,030	-

PLATES



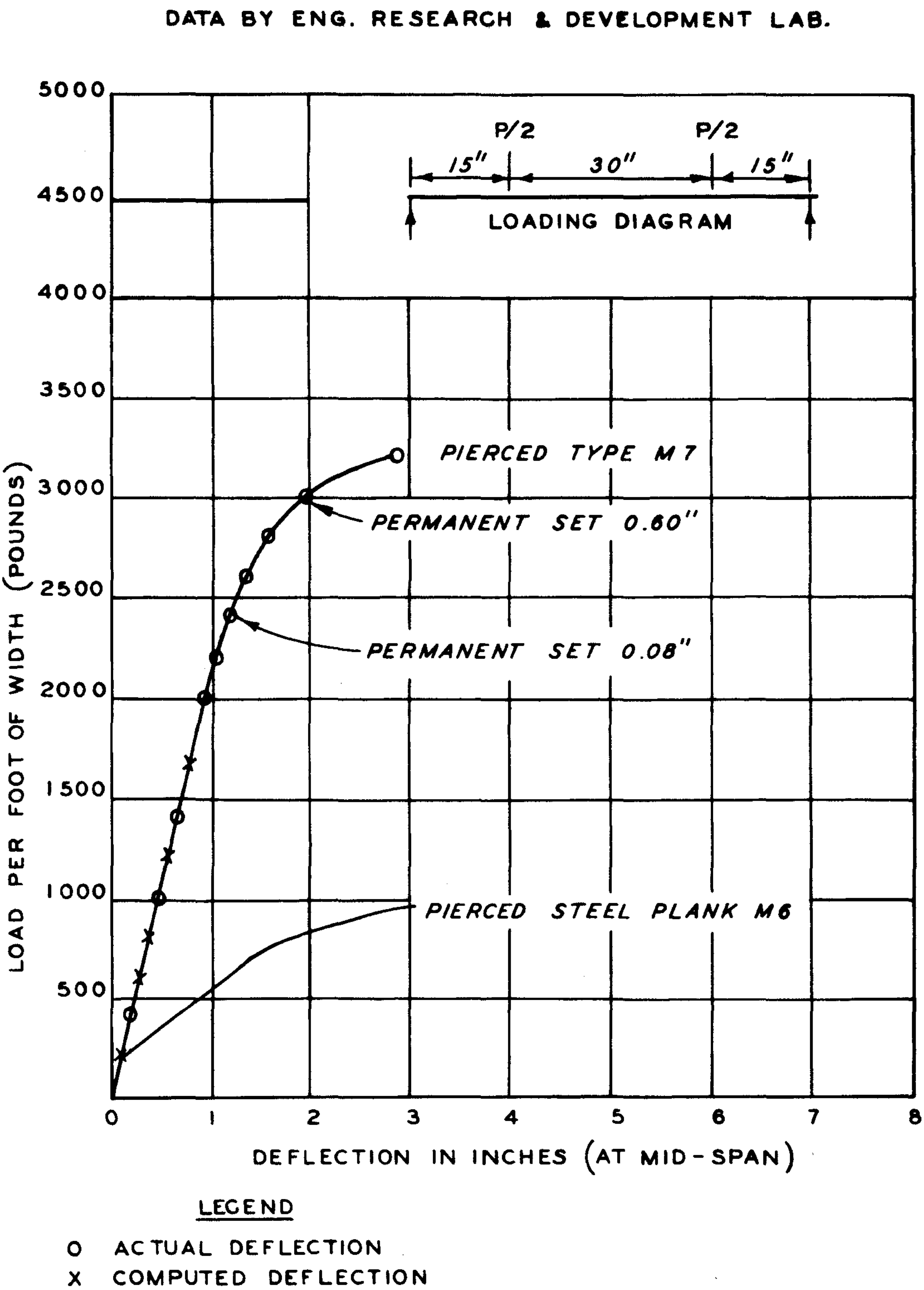
Typical bundle of M7 landing mat

PLATE 1



A -- M7, single end connectors; B -- M7, double end connector; C -- M6

Three types of mat tested

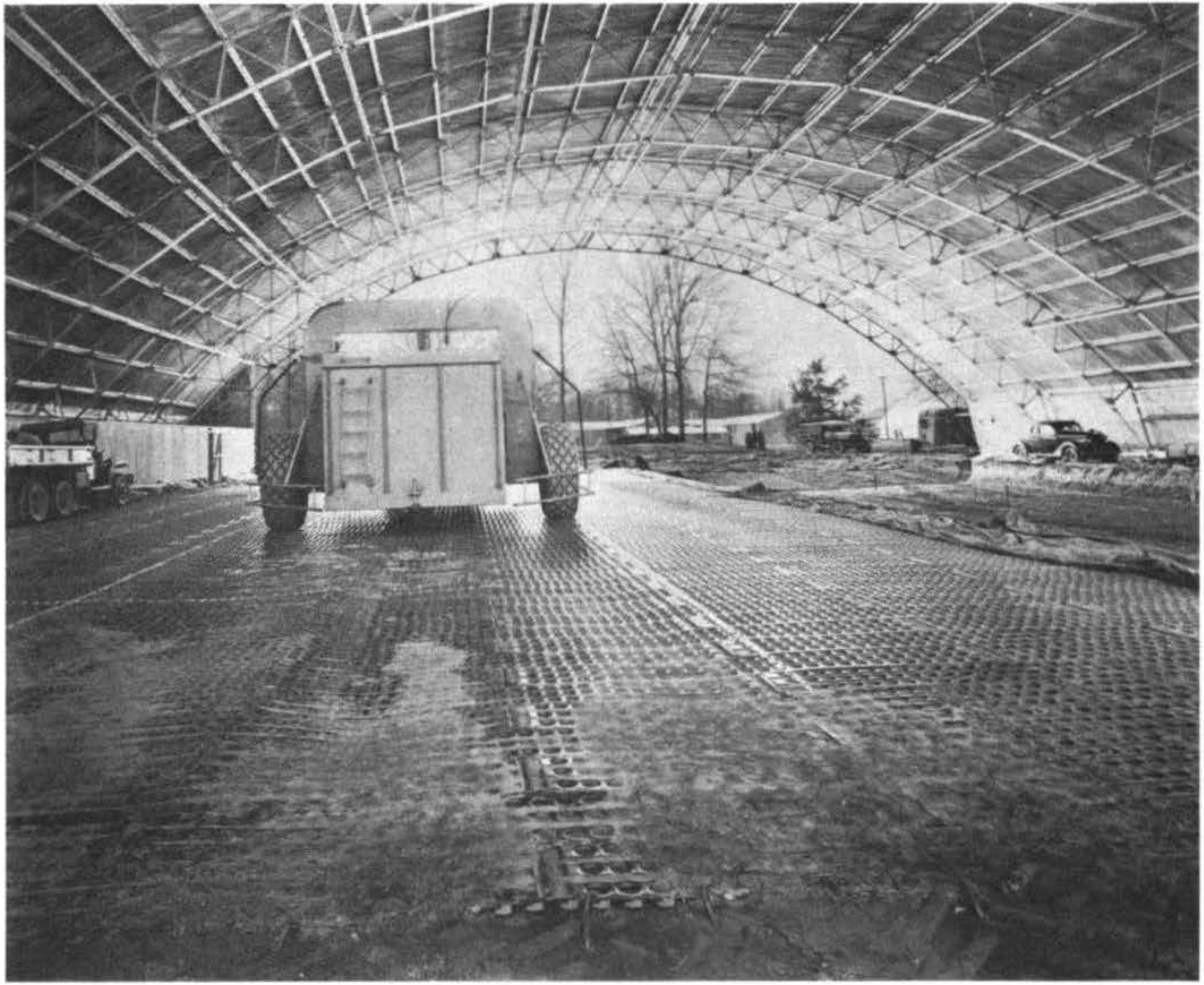


RESULTS OF DEFLECTION TEST ON
PIERCED STEEL PLANK AND
AIRPLANE LANDING MAT STEEL PIERCED TYPE M7

PLATE 4

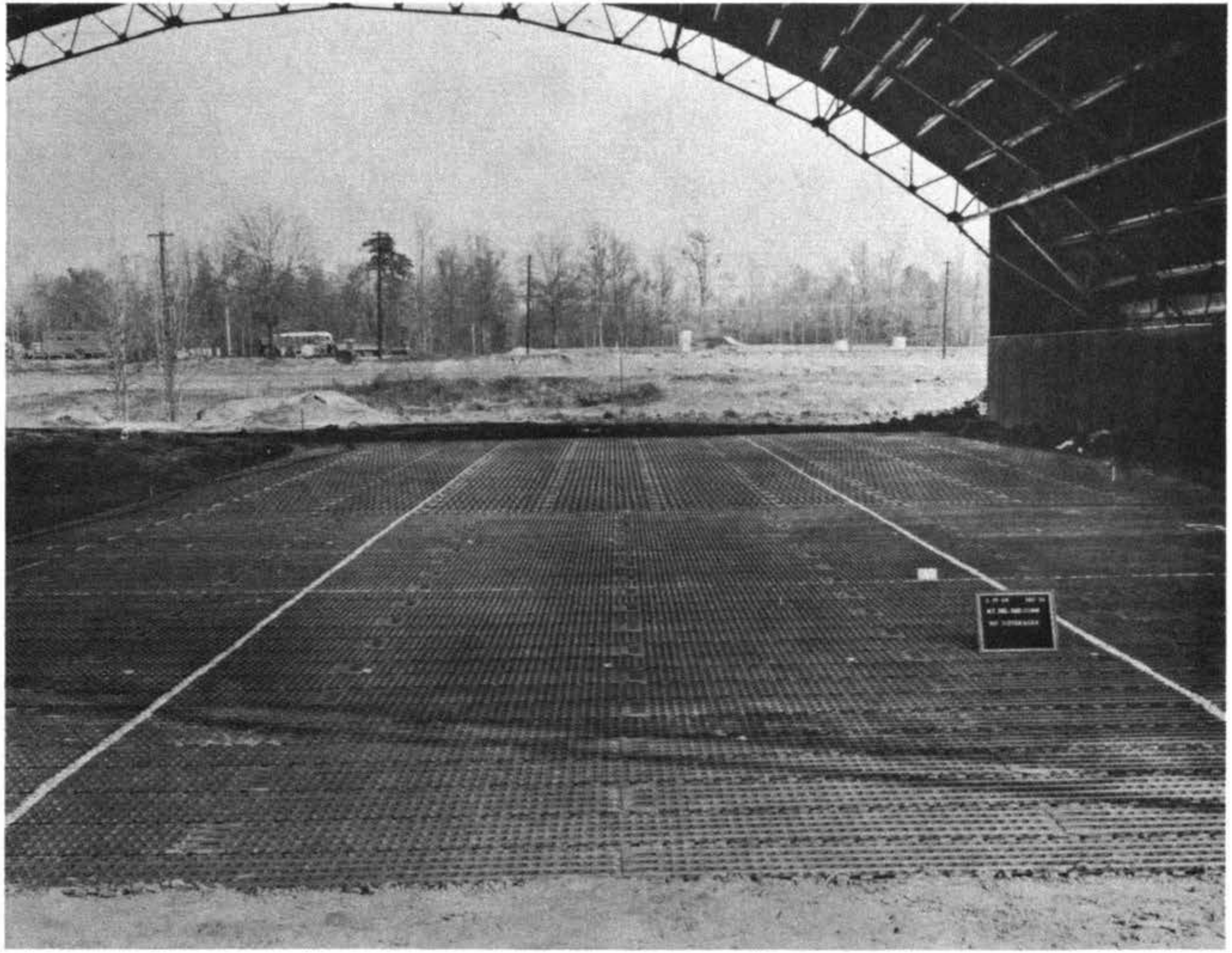
Airplane hangar under which test site was located

PLATE 5

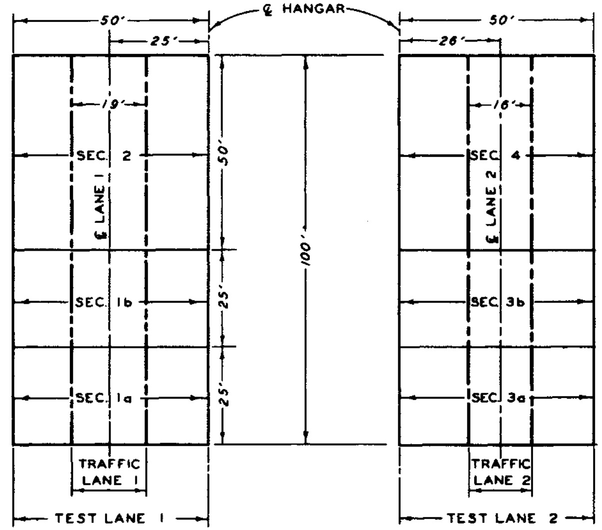


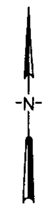
Interior view of hangar showing runway load testing device

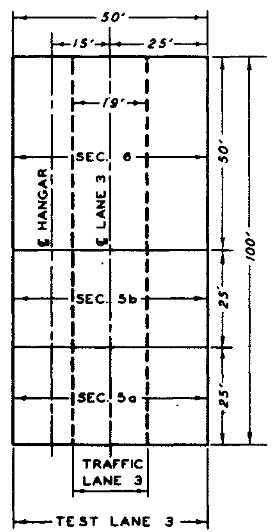
PLATE 6

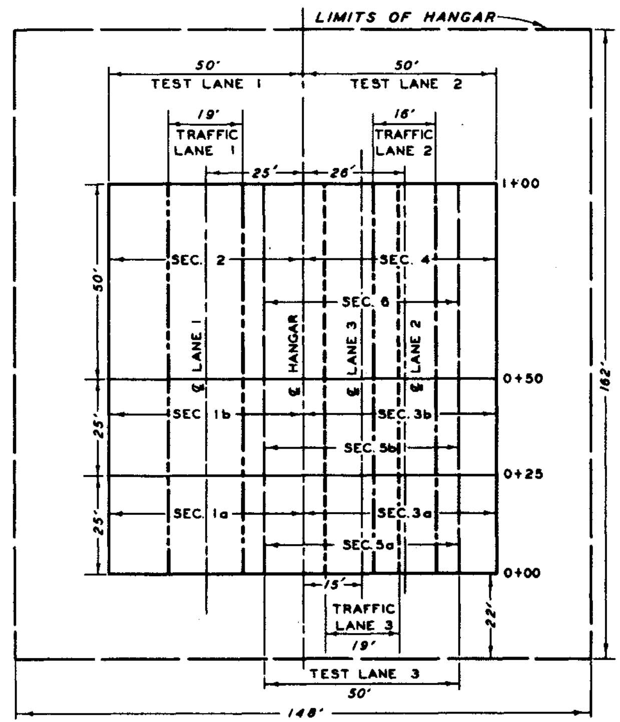


Interior view of hangar. Test lane 2, subsection 3a, with subsection 3b in background, showing M7 mat before traffic test.









LEGEND

SECTION	MAT
1a	M7 - SINGLE END CONNECTOR - HALF OF LUGS ENGAGED.
1b	M7 - SINGLE END CONNECTOR - ALL LUGS ENGAGED.
2	M6
3a	M7 - DOUBLE END CONNECTOR - HALF OF LUGS ENGAGED.
3b	M7 - DOUBLE END CONNECTOR - ALL LUGS ENGAGED.
4	M6
5a	M7 - SINGLE END CONNECTOR - HALF OF LUGS ENGAGED.
5b	M7 - SINGLE END CONNECTOR - ALL LUGS ENGAGED.
6	M6

M7 LANDING MAT TEST

LAYOUT OF TEST SECTIONS

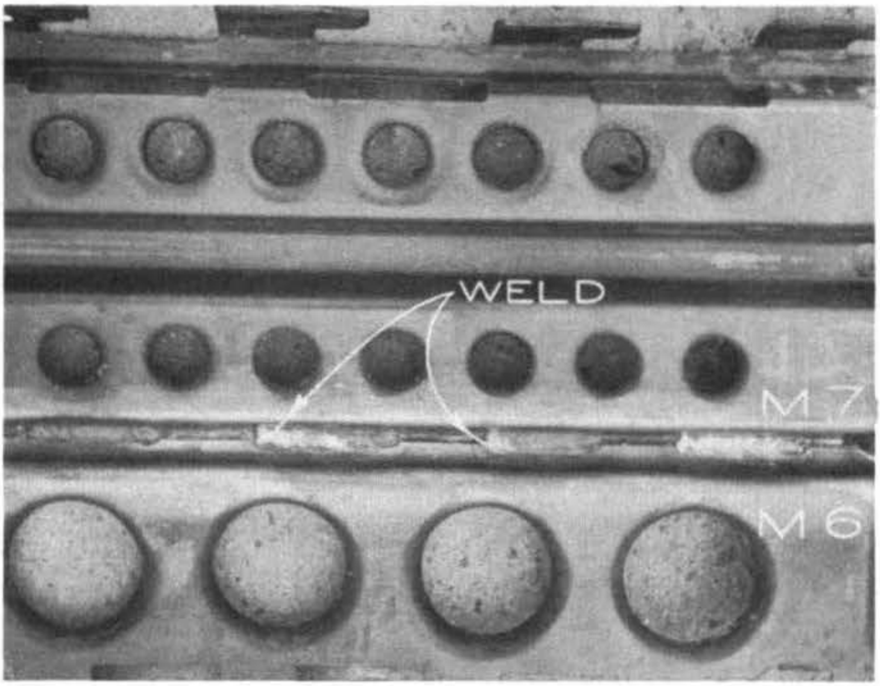


Fig. 1. Details of weld

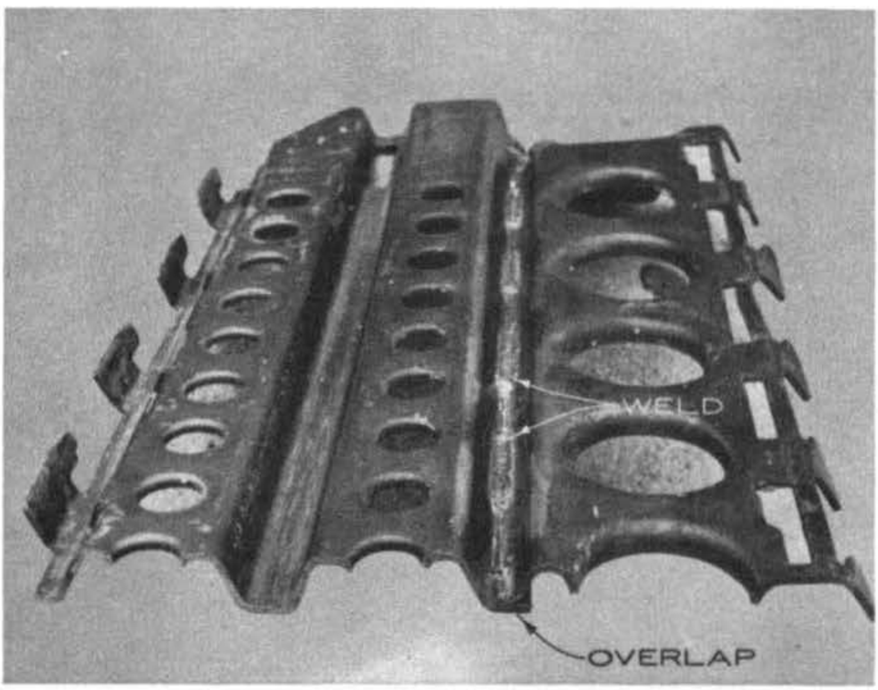


Fig. 2. Details of weld and overlap

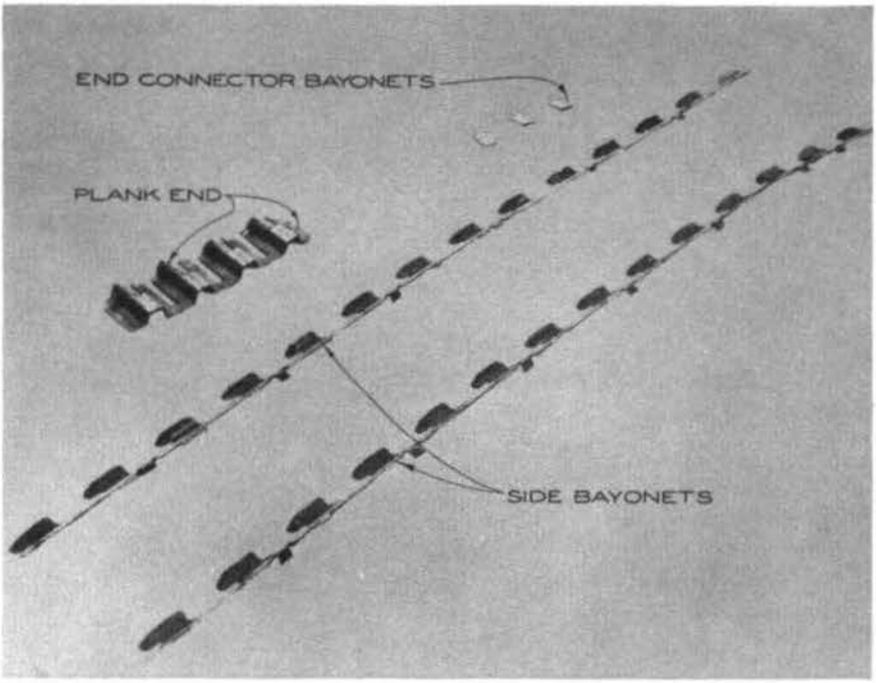


Fig. 1. Metal that must be cut away to permit removal of a single plank from area of M7 landing mat

Fig. 2. Appearance of subgrade after removal of plank at 528 coverages

Side joint

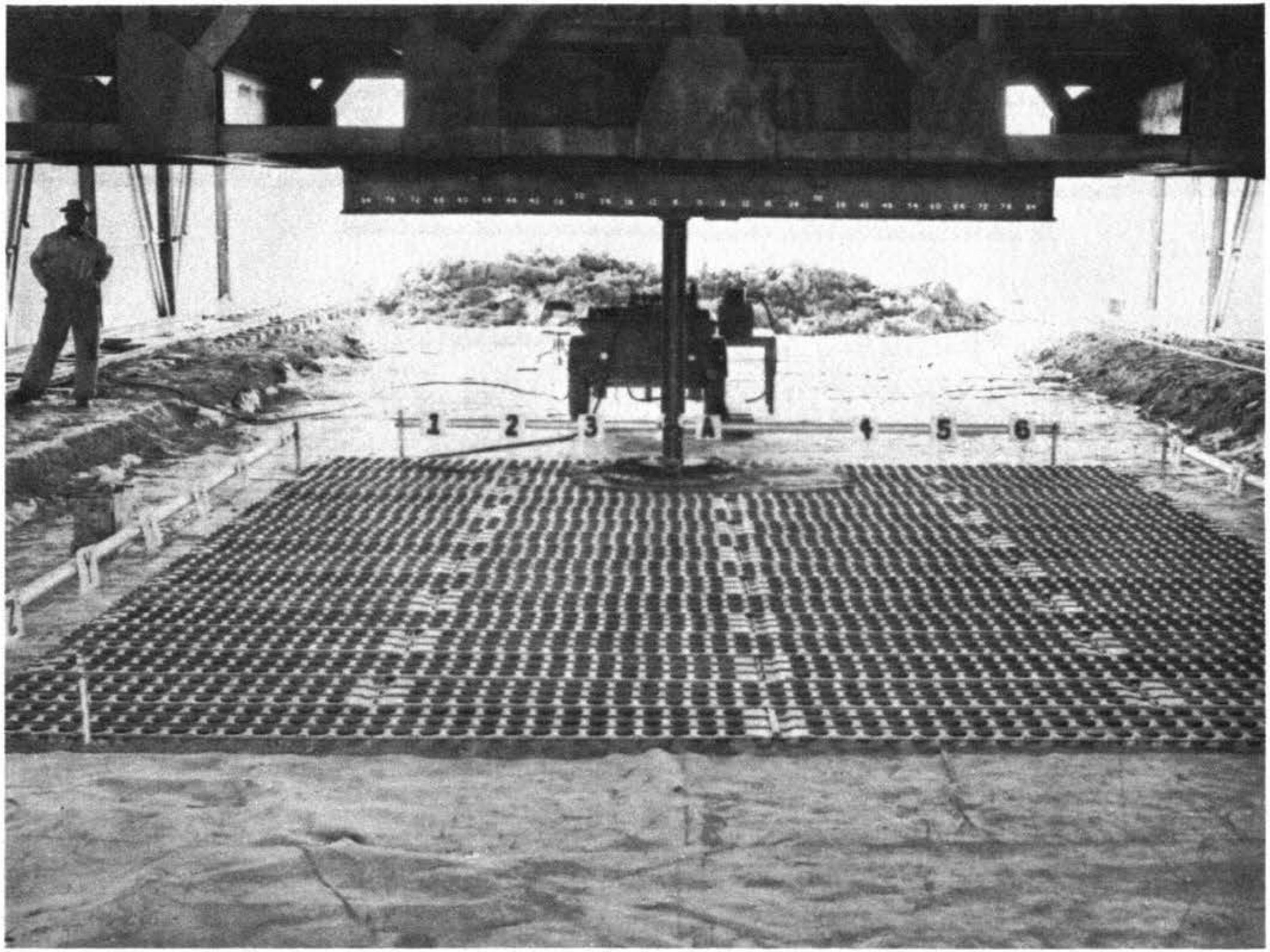
End Joint

Welded joints where plank was replaced in area of M7 landing mat

PLATE 10

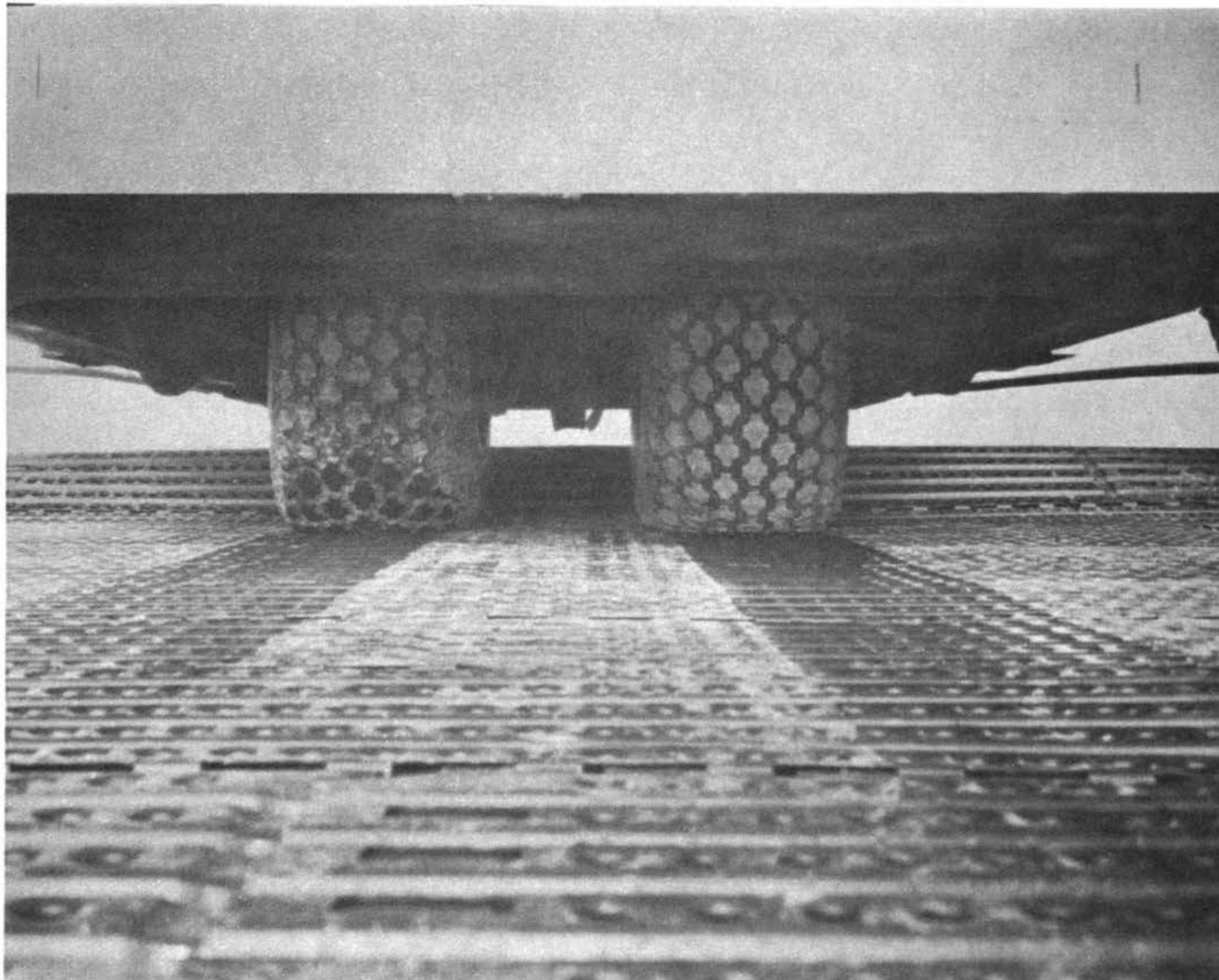
Load cart used in tire wear tests

PLATE 12

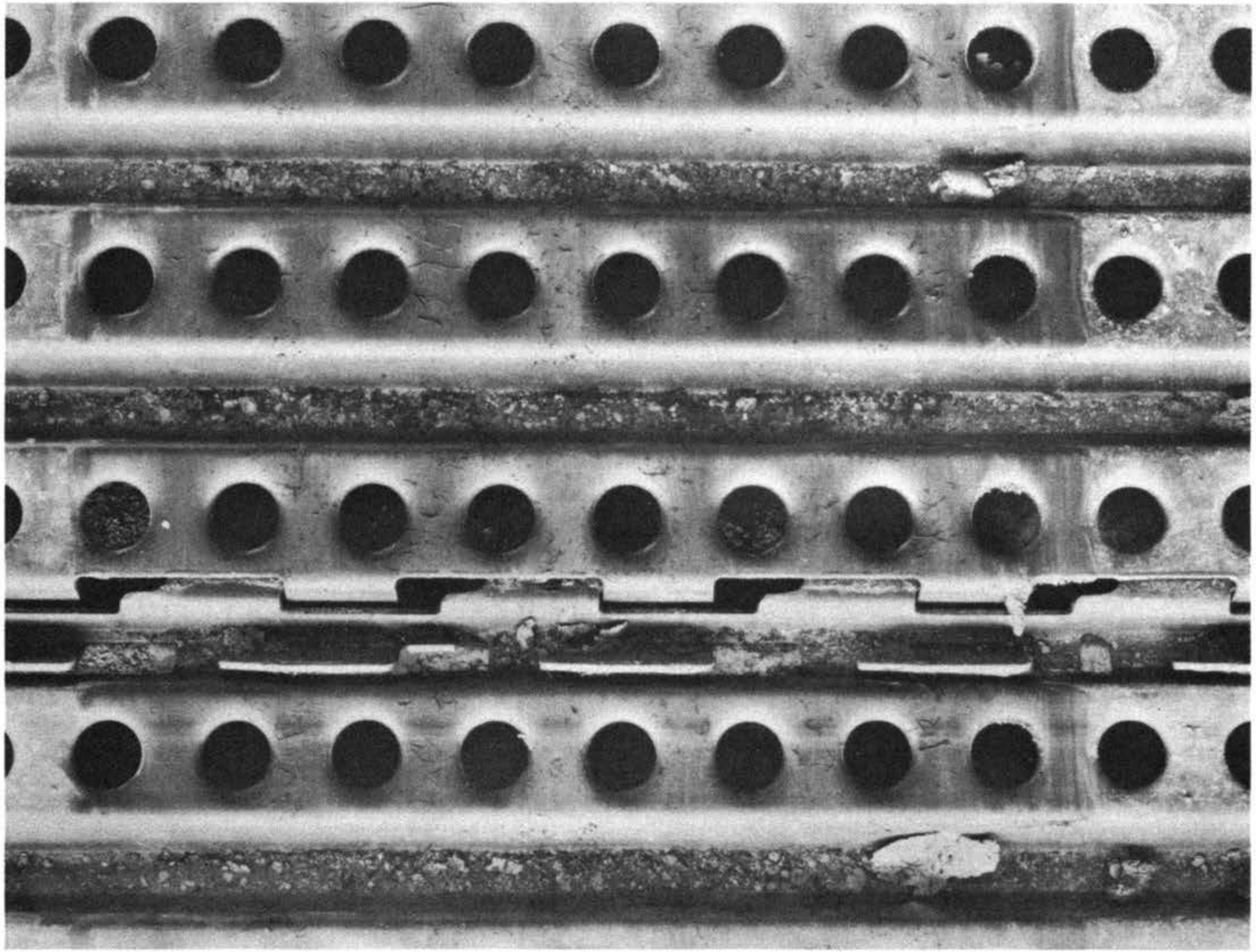


Application of test load during pressure distribution studies

PLATE 13

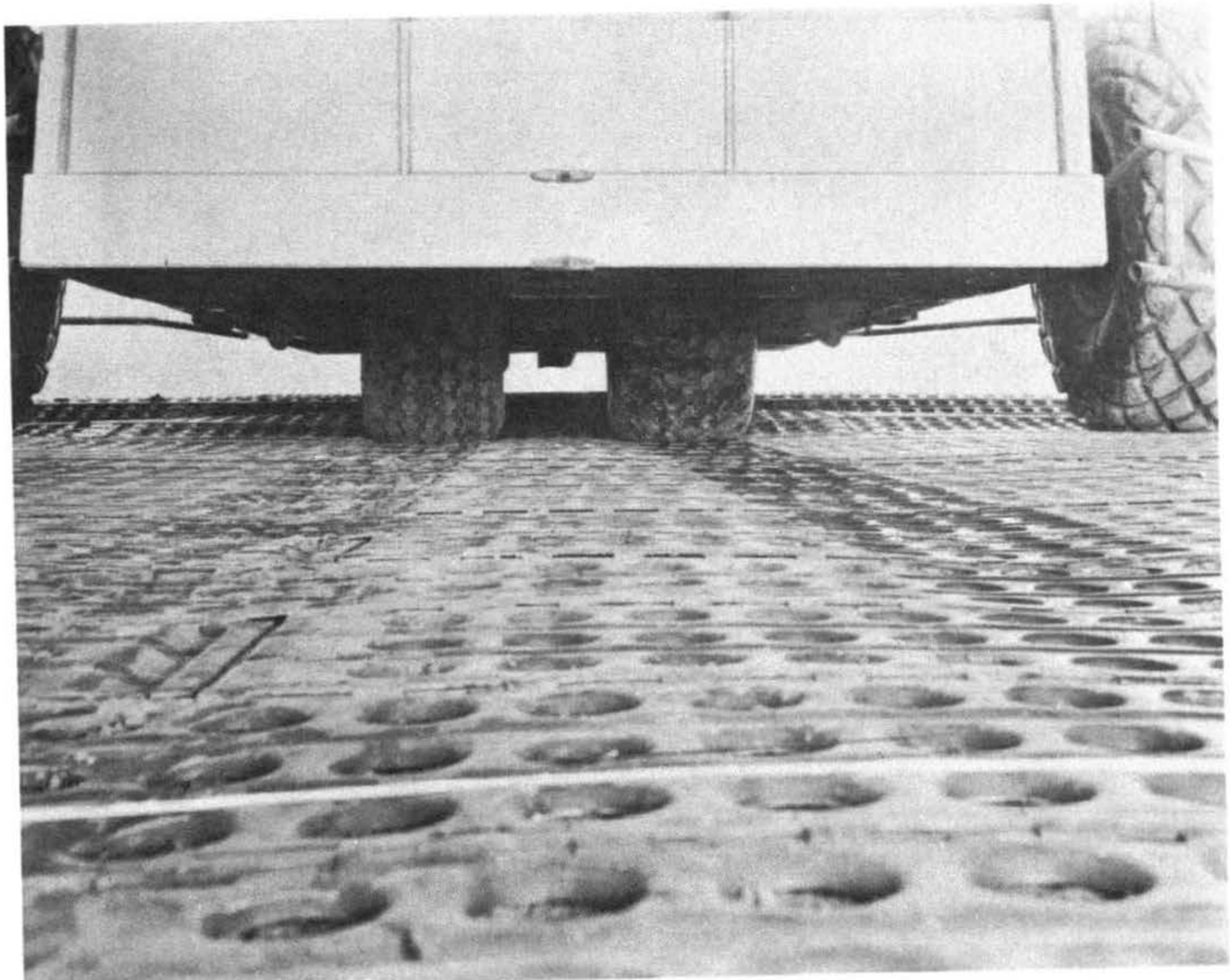


M7 mat buckled ahead of wheels in braking tests



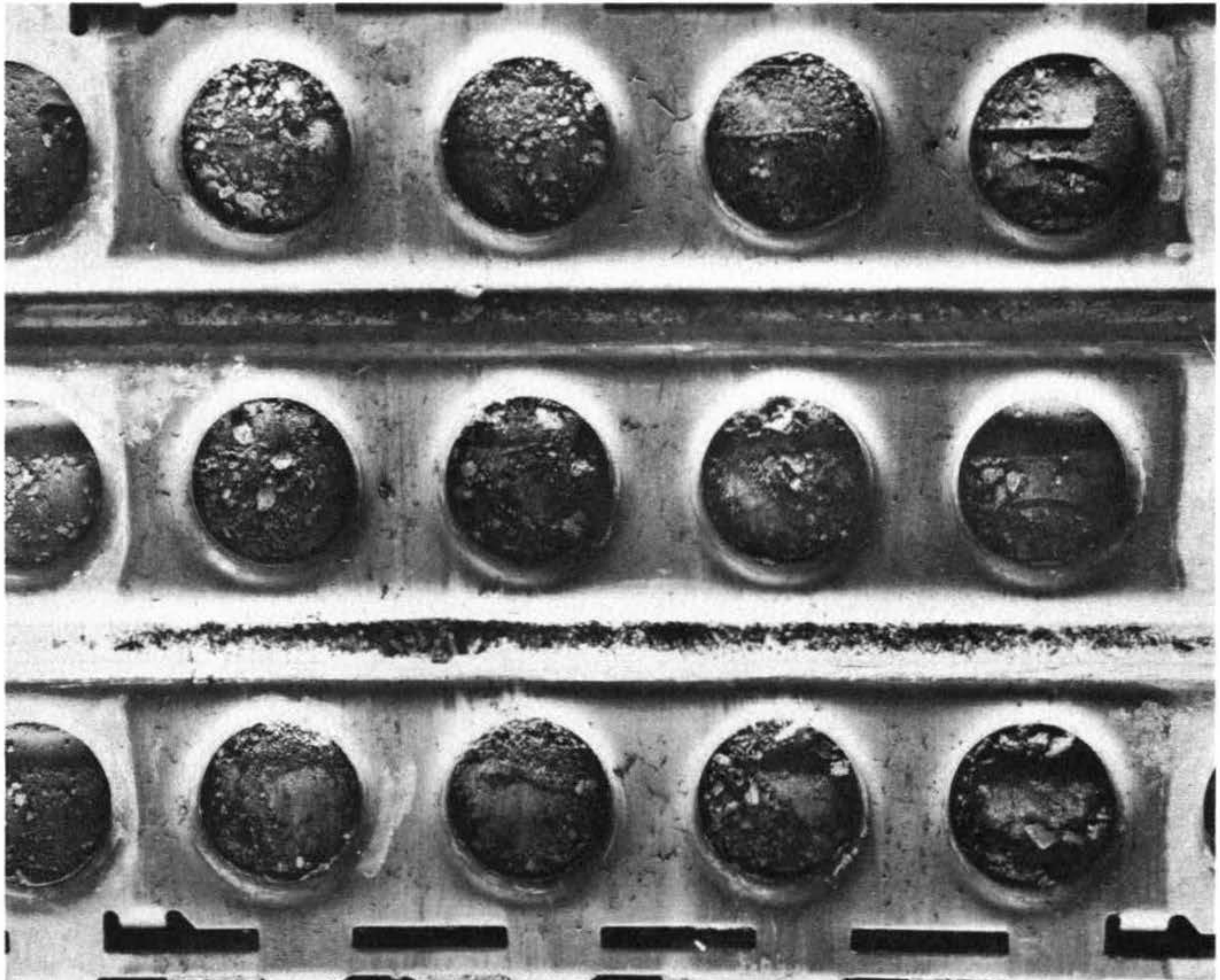
Rubber left on M7 mat behind skidding 56-in. dual tires loaded to 70,000 lb

PLATE 15



M6 mat buckled ahead of wheels in braking tests

PLATE 16



Rubber left on M6 mat behind skidding 56-in. dual tires loaded to 70,000 lb

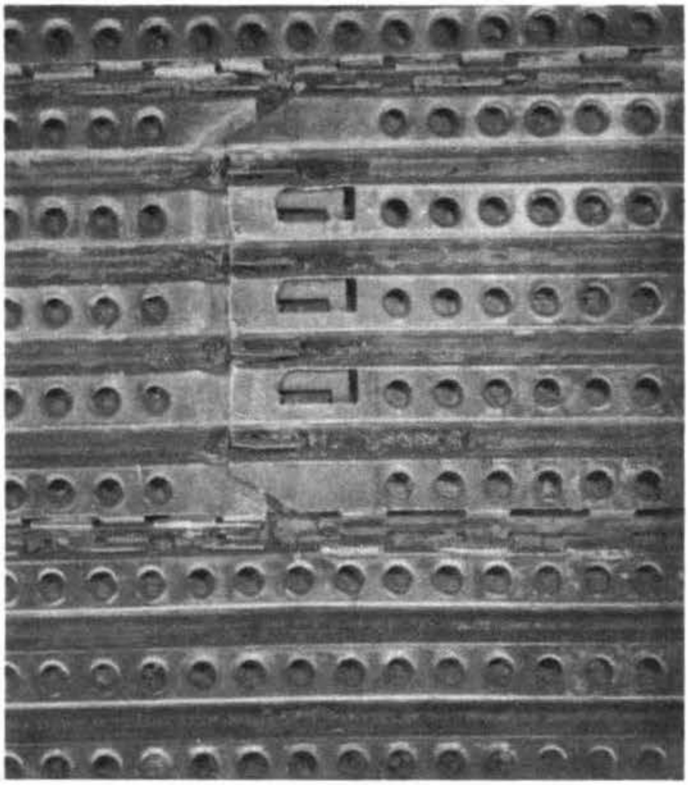


Fig. 1. Rubber left on M7 mat where tire skidded over joints

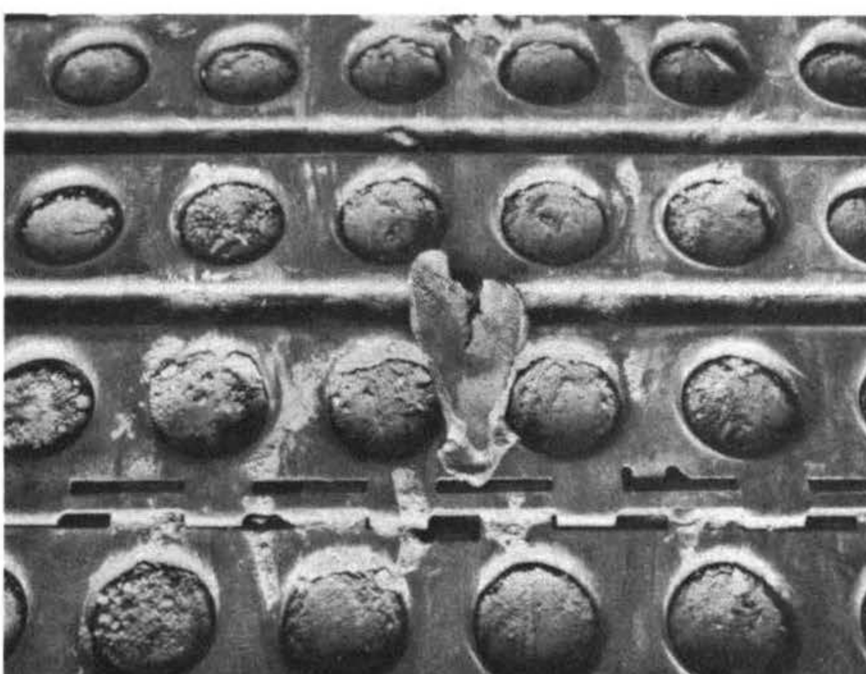
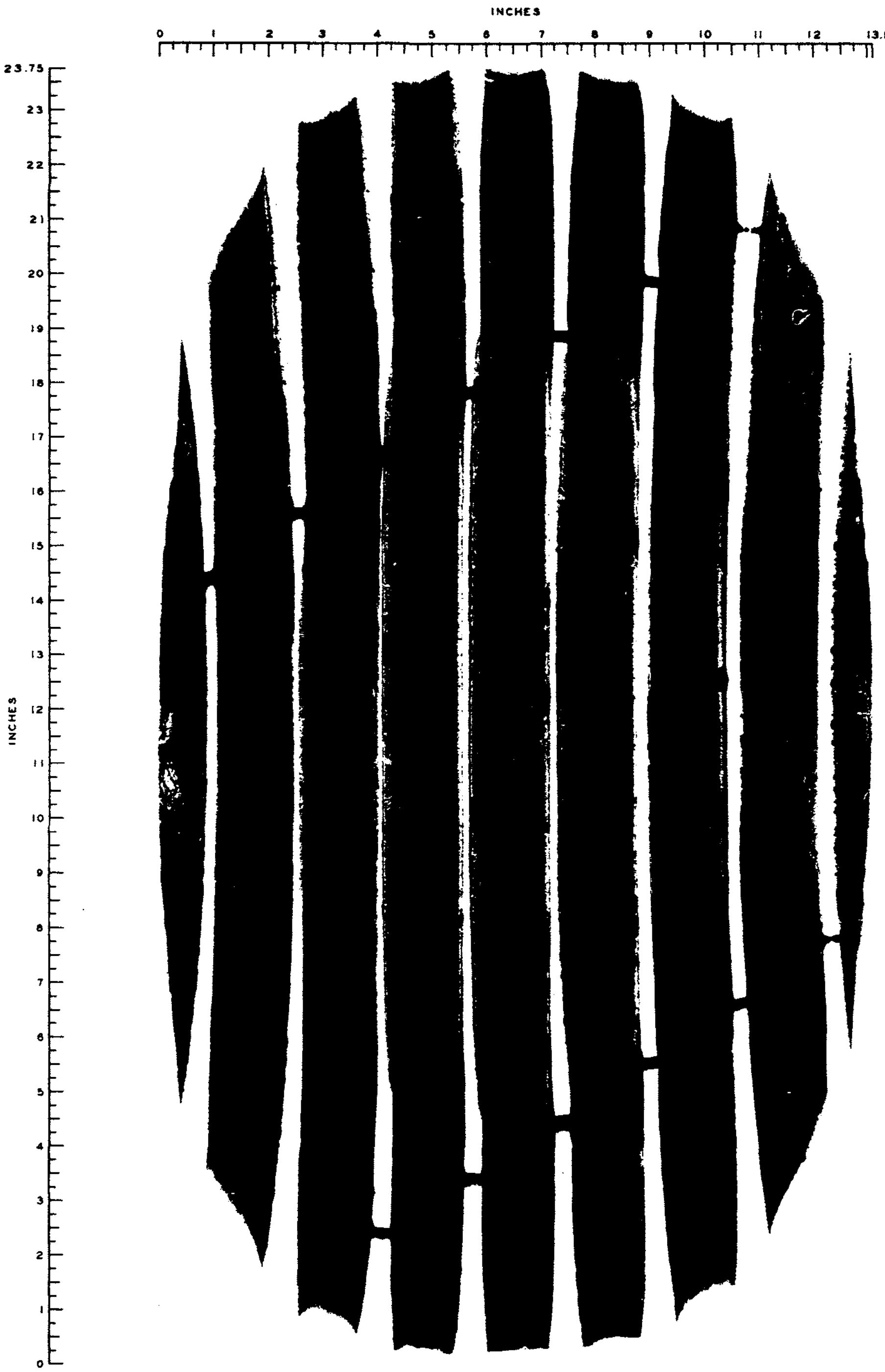


Fig. 2. Large piece of rubber torn from tire during braking test on M6 mat -- bedded



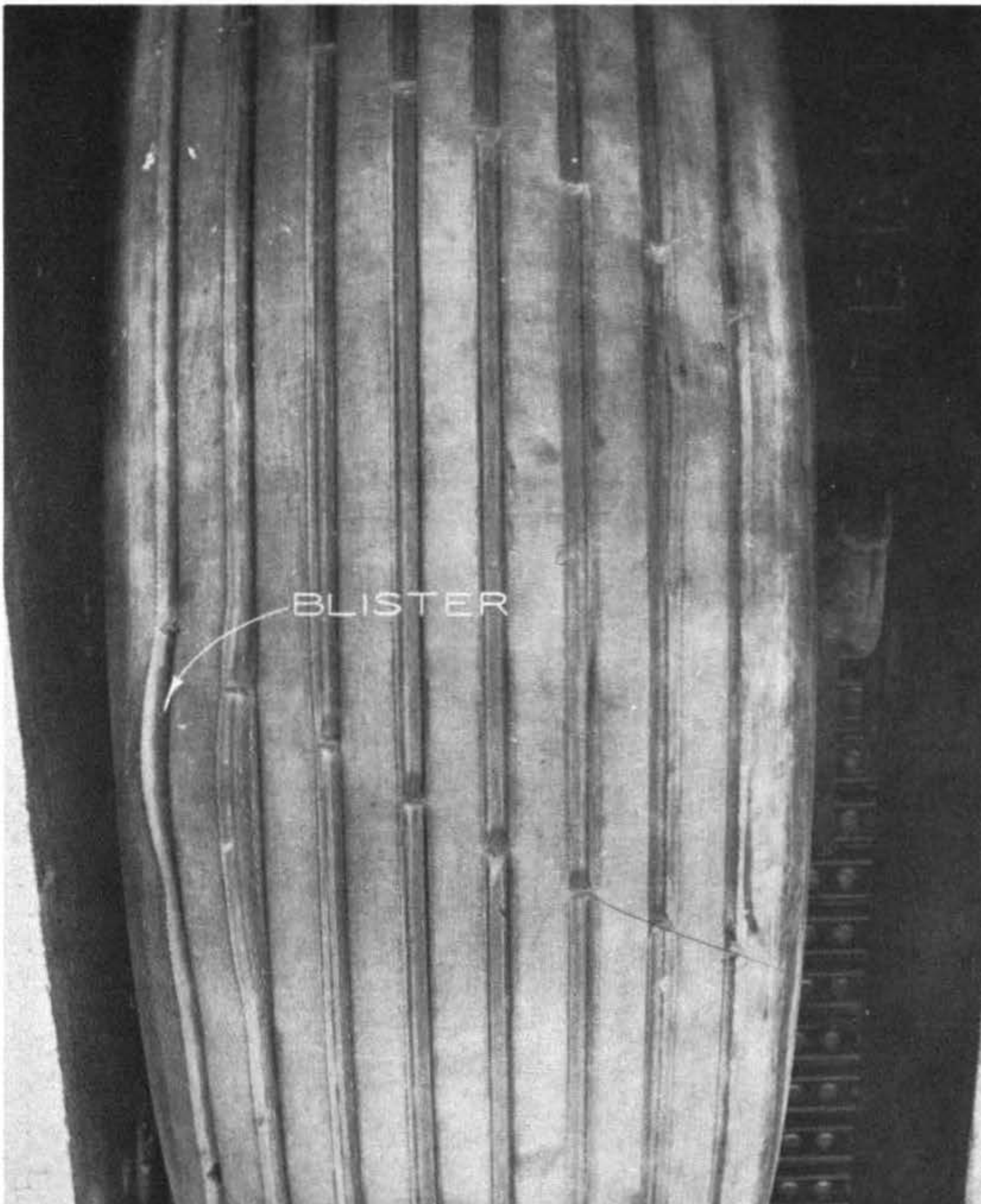
56 X 16 20-PLY RATING NYLON AIRPLANE TIRE

GROSS LOAD	50,000 POUNDS
INFLATION PRESSURE	200 PSI
GROSS CONTACT AREA	263 SQ. IN.
CONTACT PRESSURE (GROSS AREA)	190 PSI
NET CONTACT AREA	221 SQ. IN.
CONTACT PRESSURE (NET AREA)	226 PSI

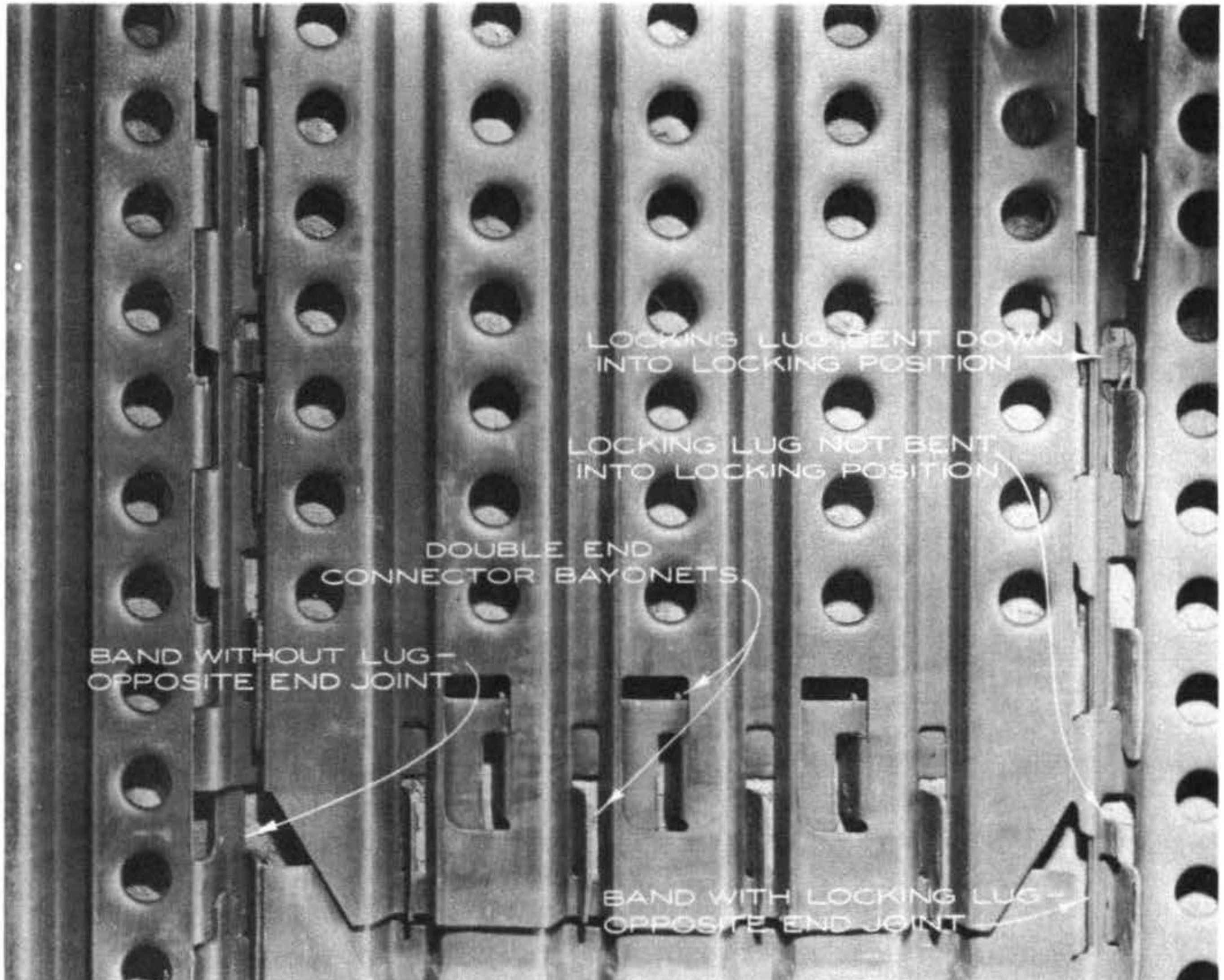
M7 LANDING MAT TEST

PRINT OF HIGH PRESSURE TIRE

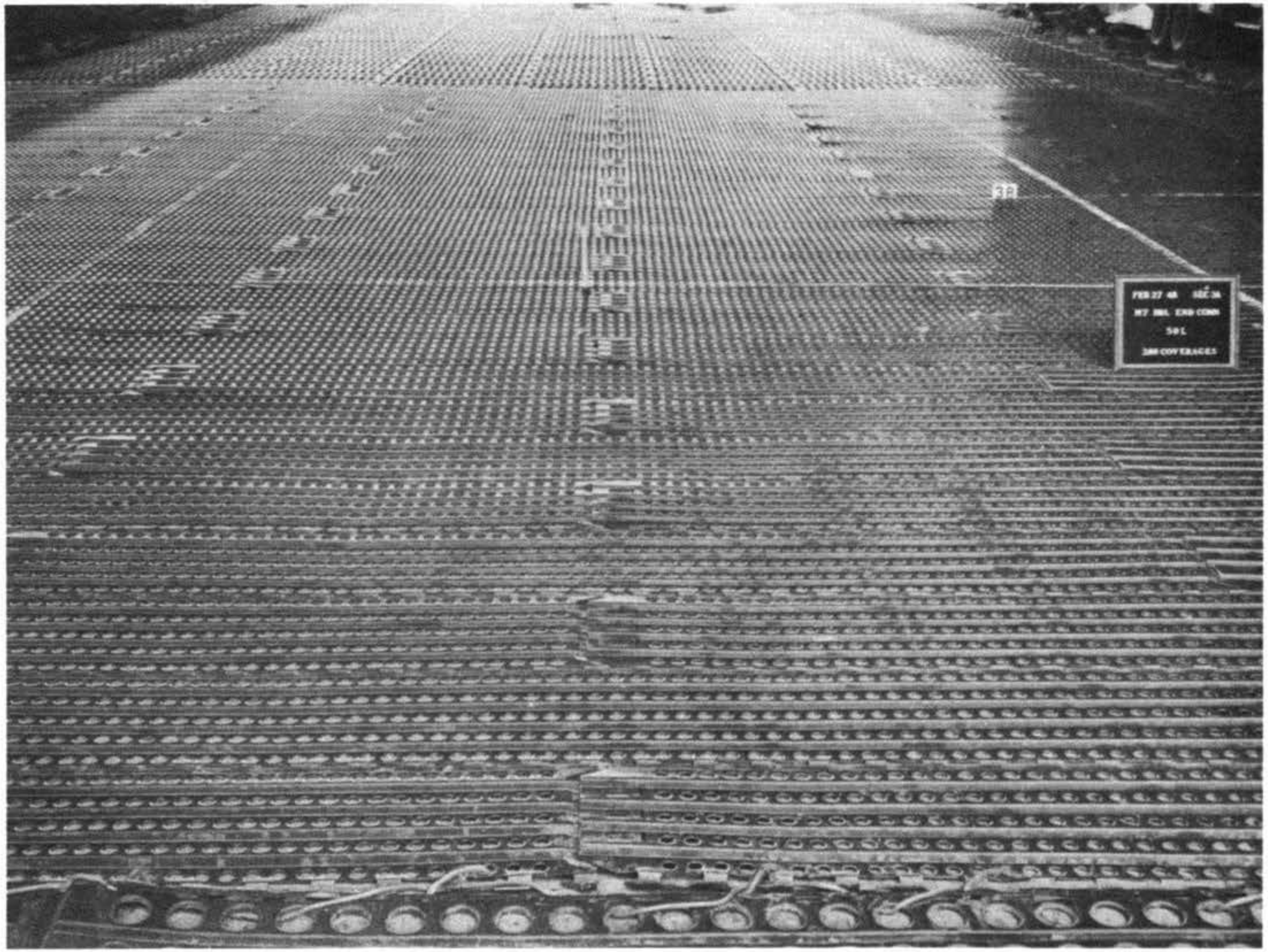
PLATE 18



Failure of 200-psi tire after 966 coverages
(note blister on left side of tire in center of photograph)

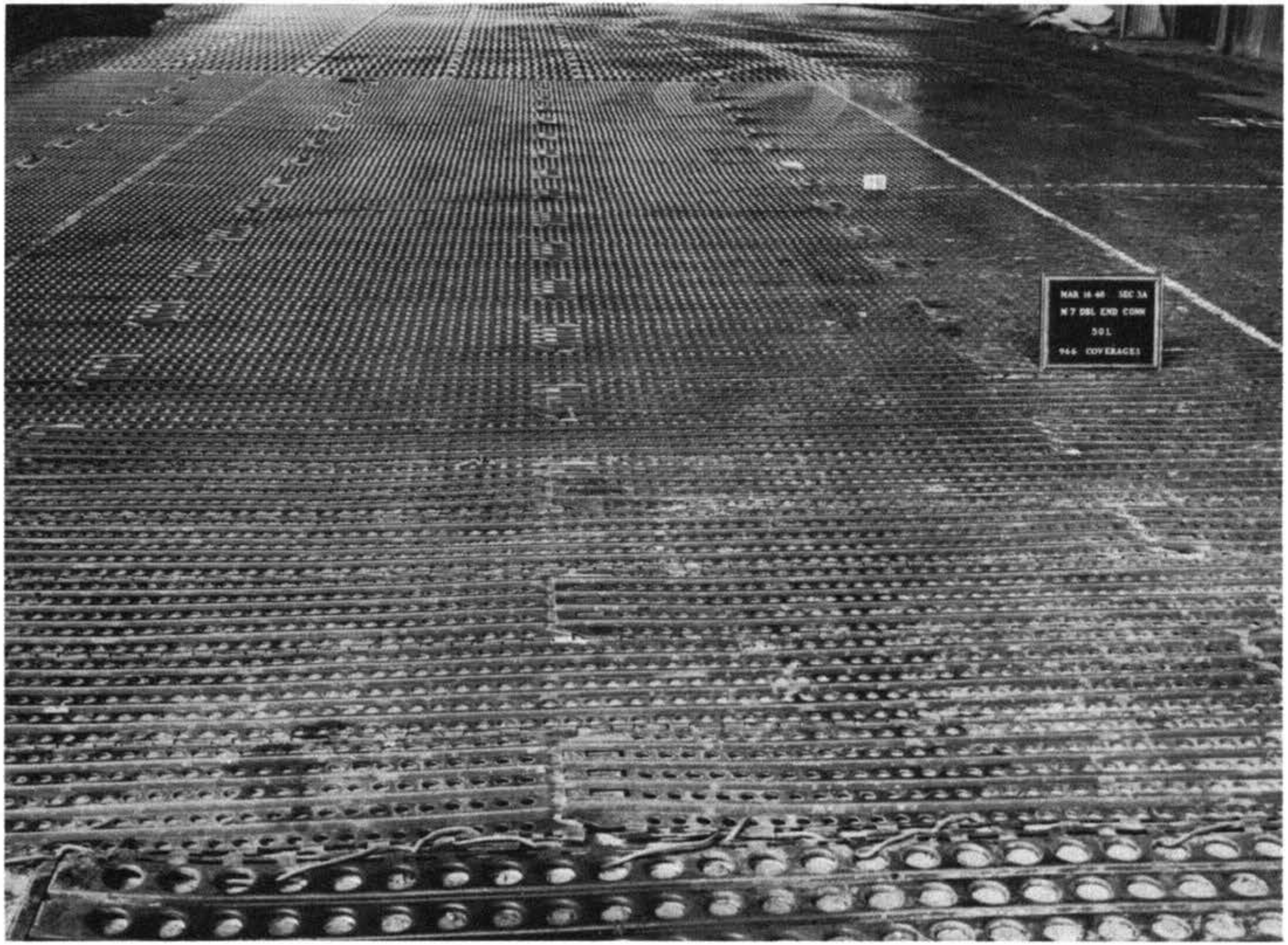


Details of M7 mat joint



Subsection 3a, with subsection 3b in background, after 280 coverages

PLATE 21



Subsection 3a after 966 coverages

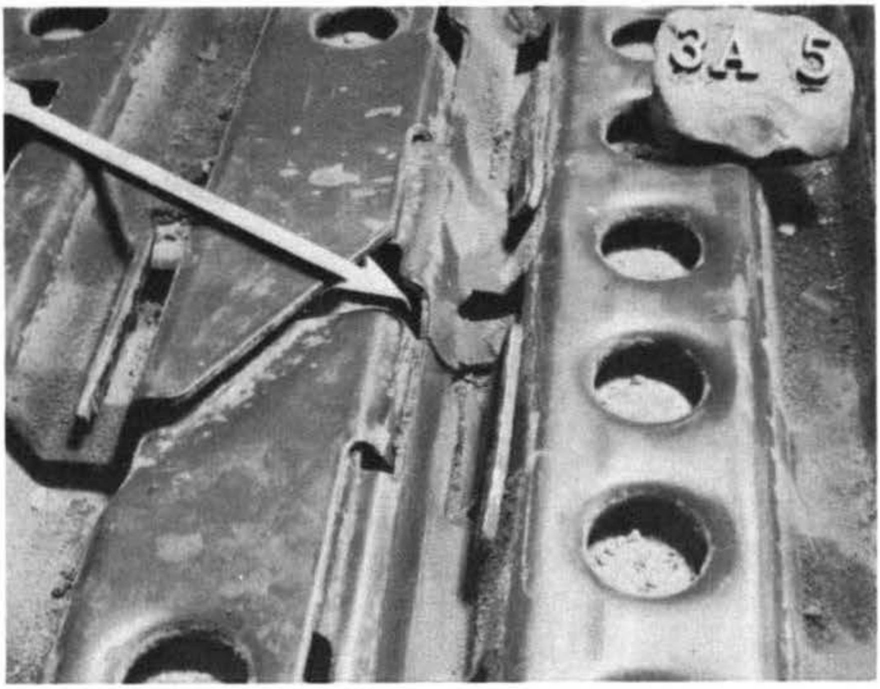


Fig. 1. Typical break in narrow band carrying locking lugs

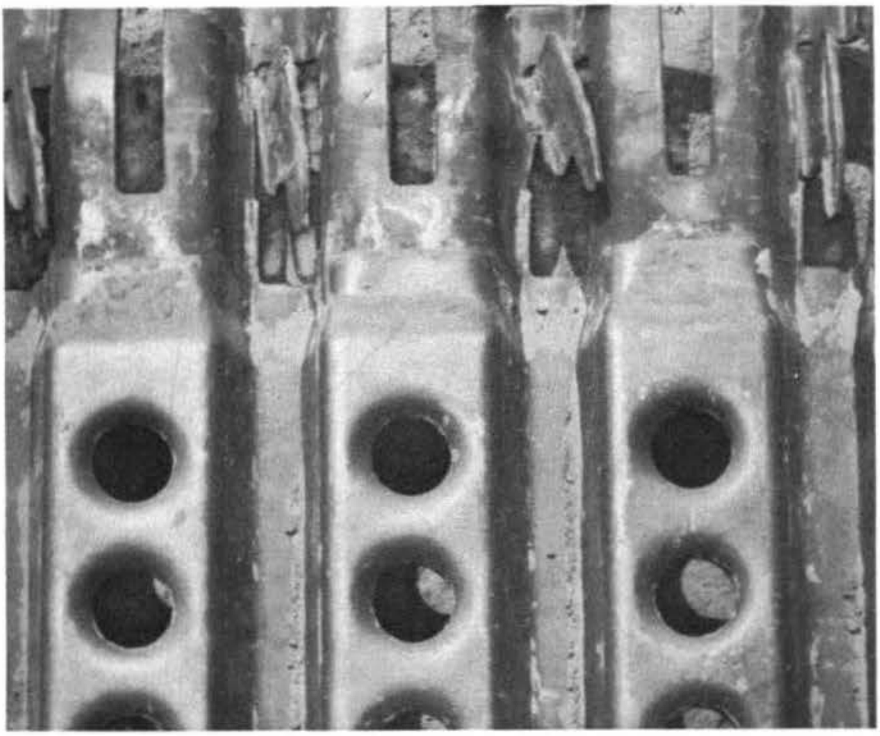
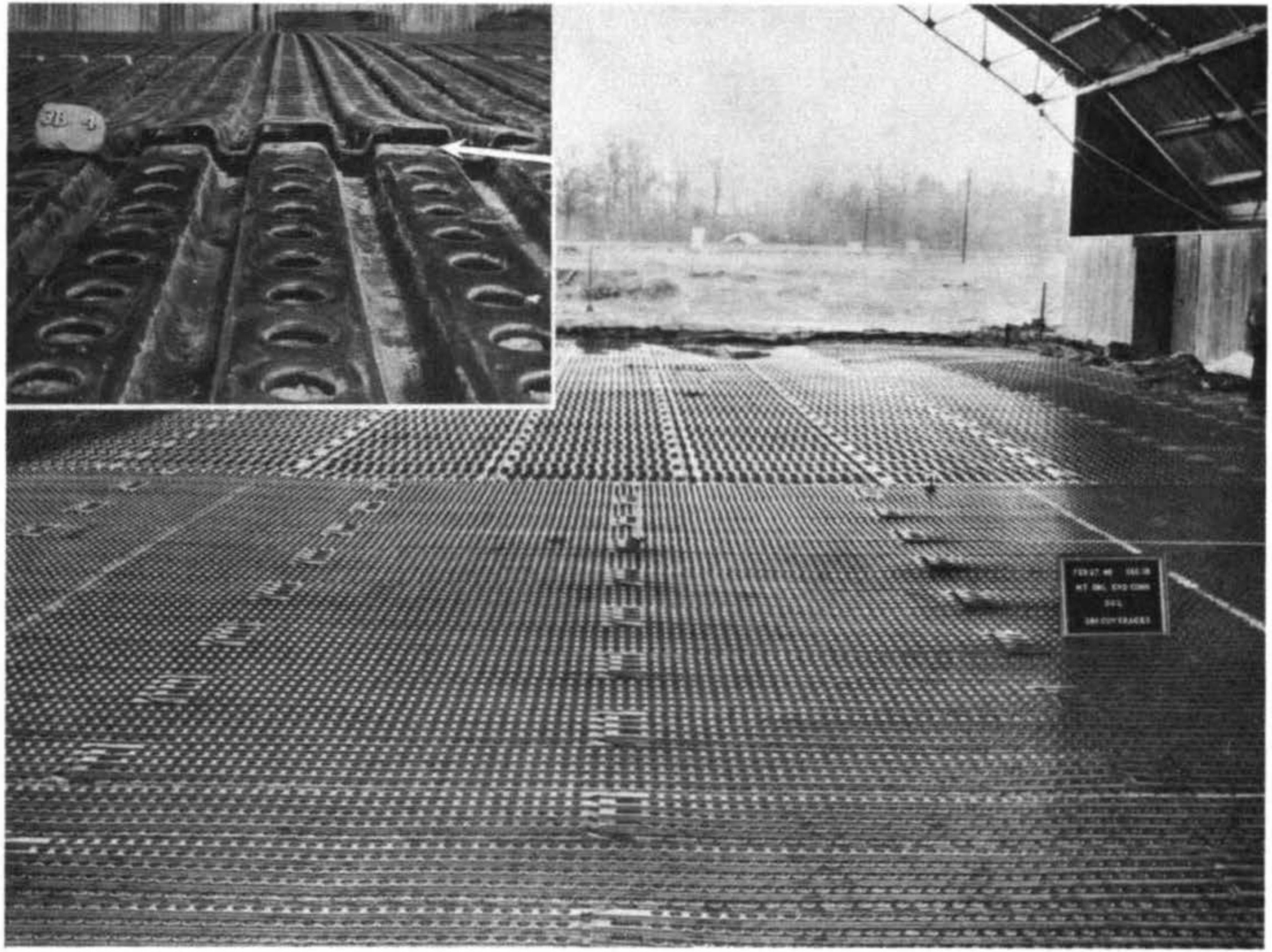
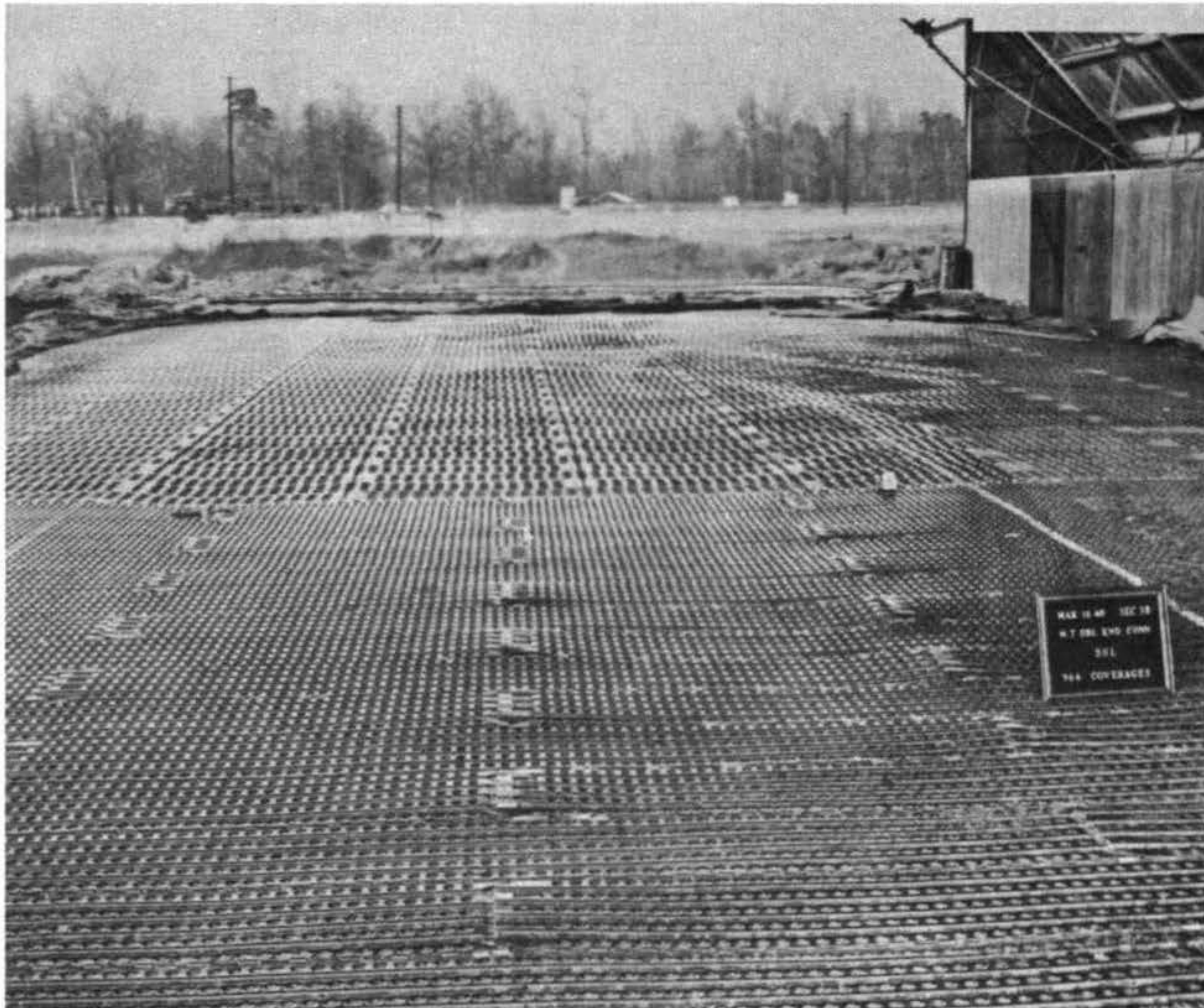


Fig. 2. Typical end connector breaks on M7 mat
with double end connectors



M7 mat subsection 3b after 280 coverages
Note end joints opening up in right foreground



M7 mat in subsection 3b after 966 coverages

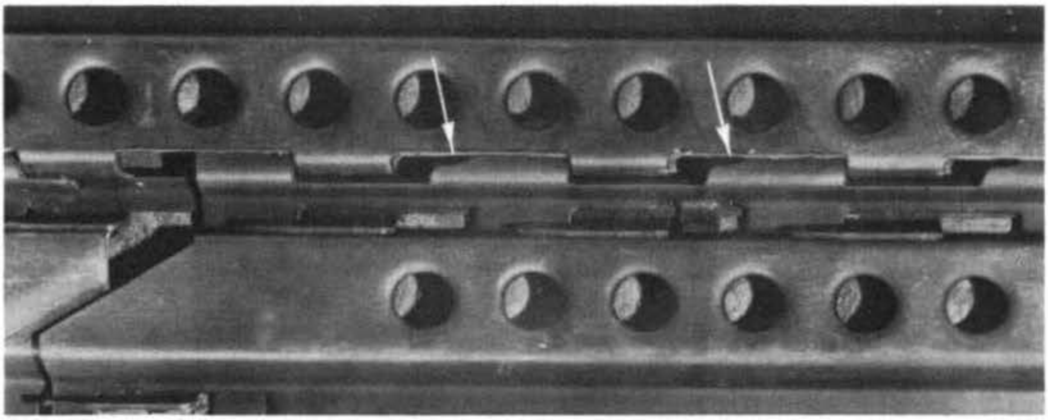


Fig. 1. Position of square shoulders at bases of horizontal bayonets on newly laid mat

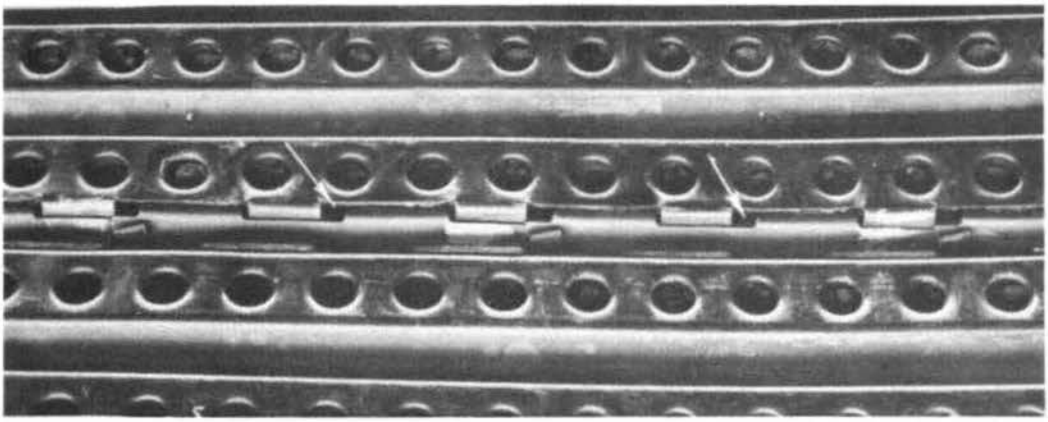


Fig. 2. Position of square shoulders at bases of horizontal bayonets during traffic test

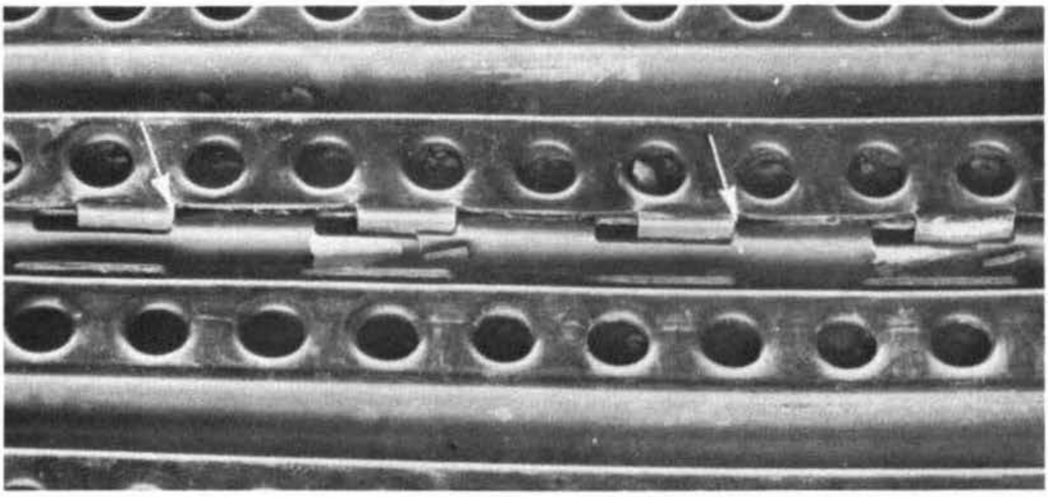
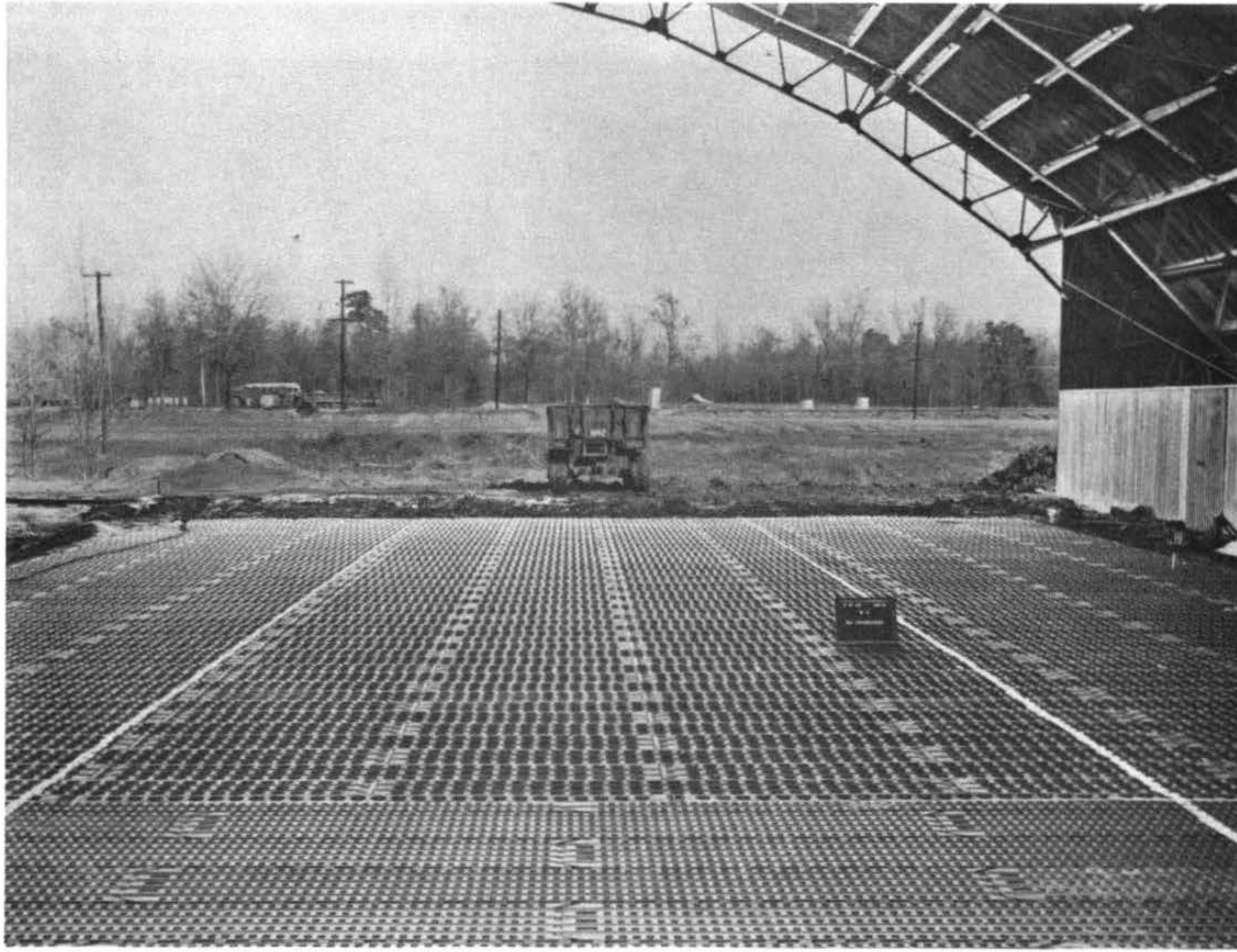
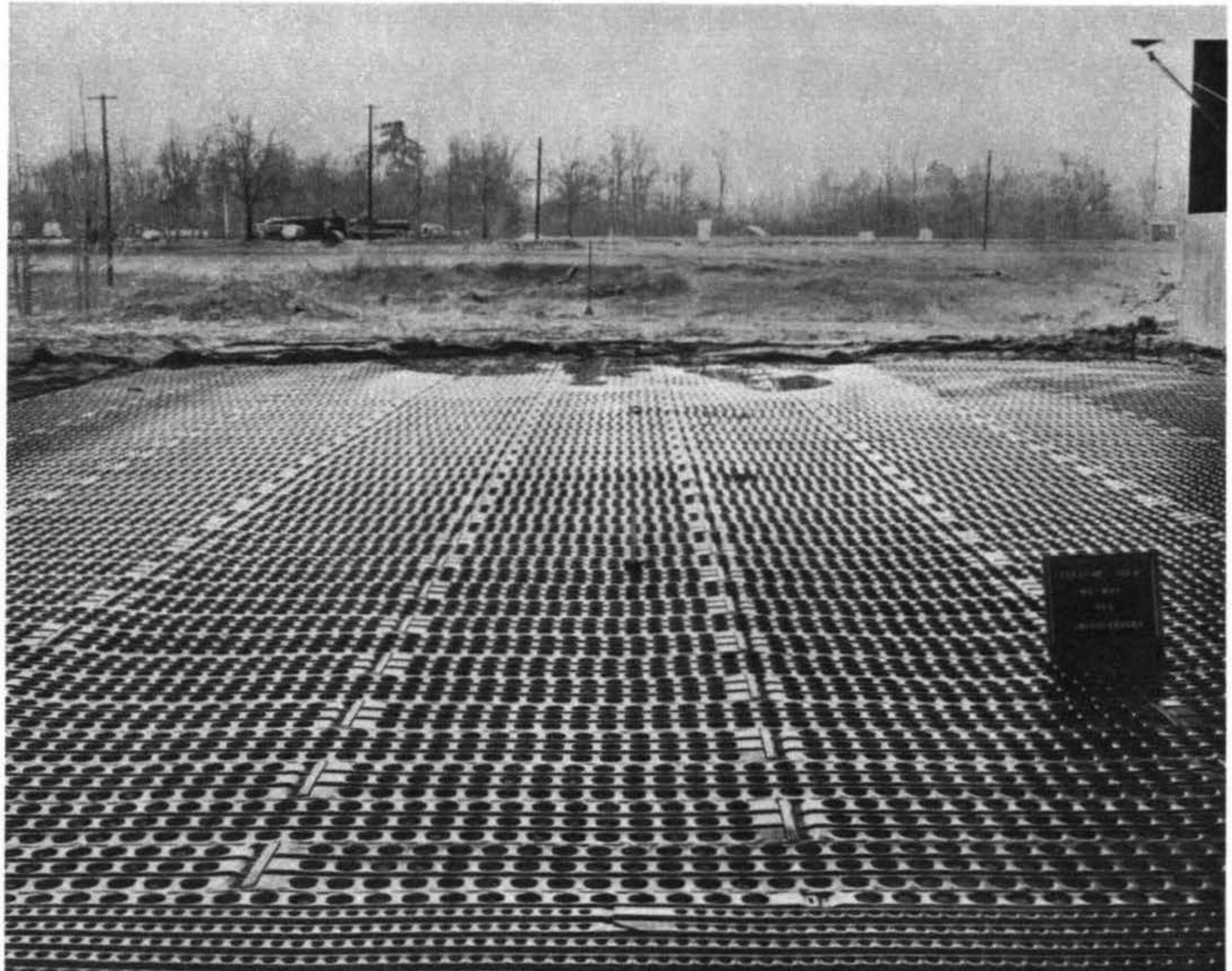


Fig. 3. Position of square shoulders at bases of horizontal bayonets during process of removal



M6 mat in section 4 before traffic testing



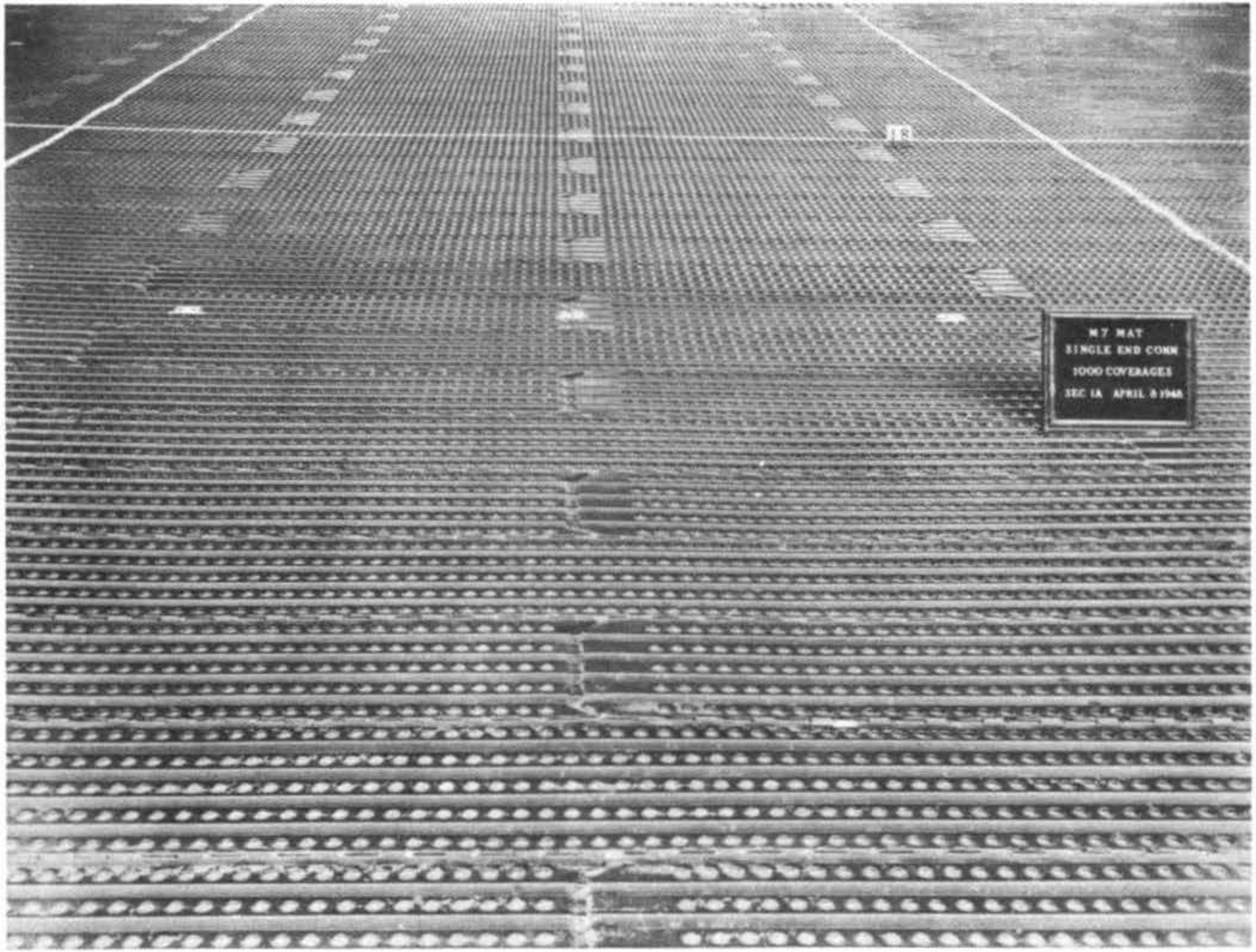
M6 mat in section 4 after 280 coverages

M6 mat in section 4 after 966 coverages

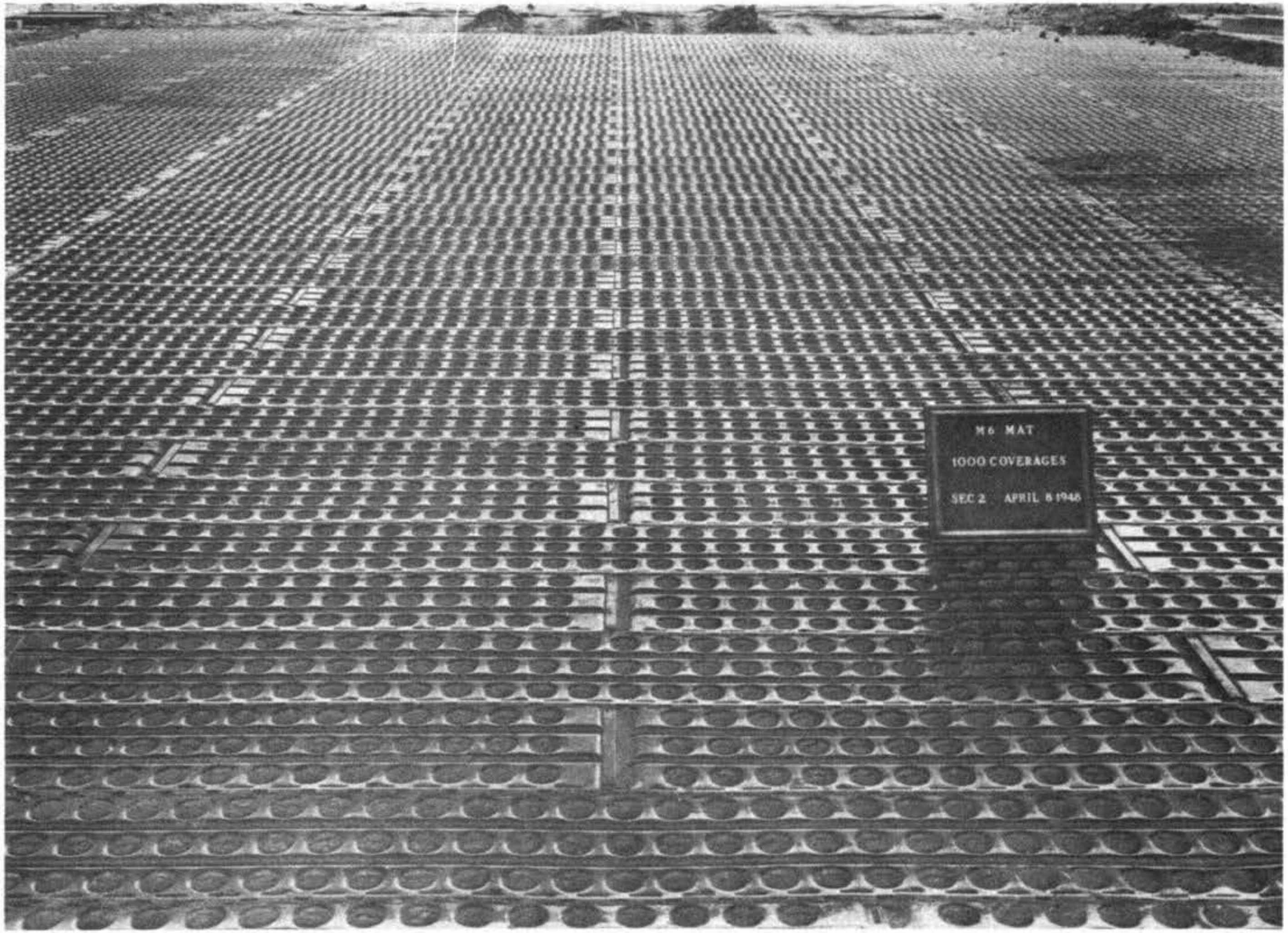
PLATE 29

PLATE 30

M7 and M6 mats in lane 1 before testing



M7 mat in lane 1 after testing



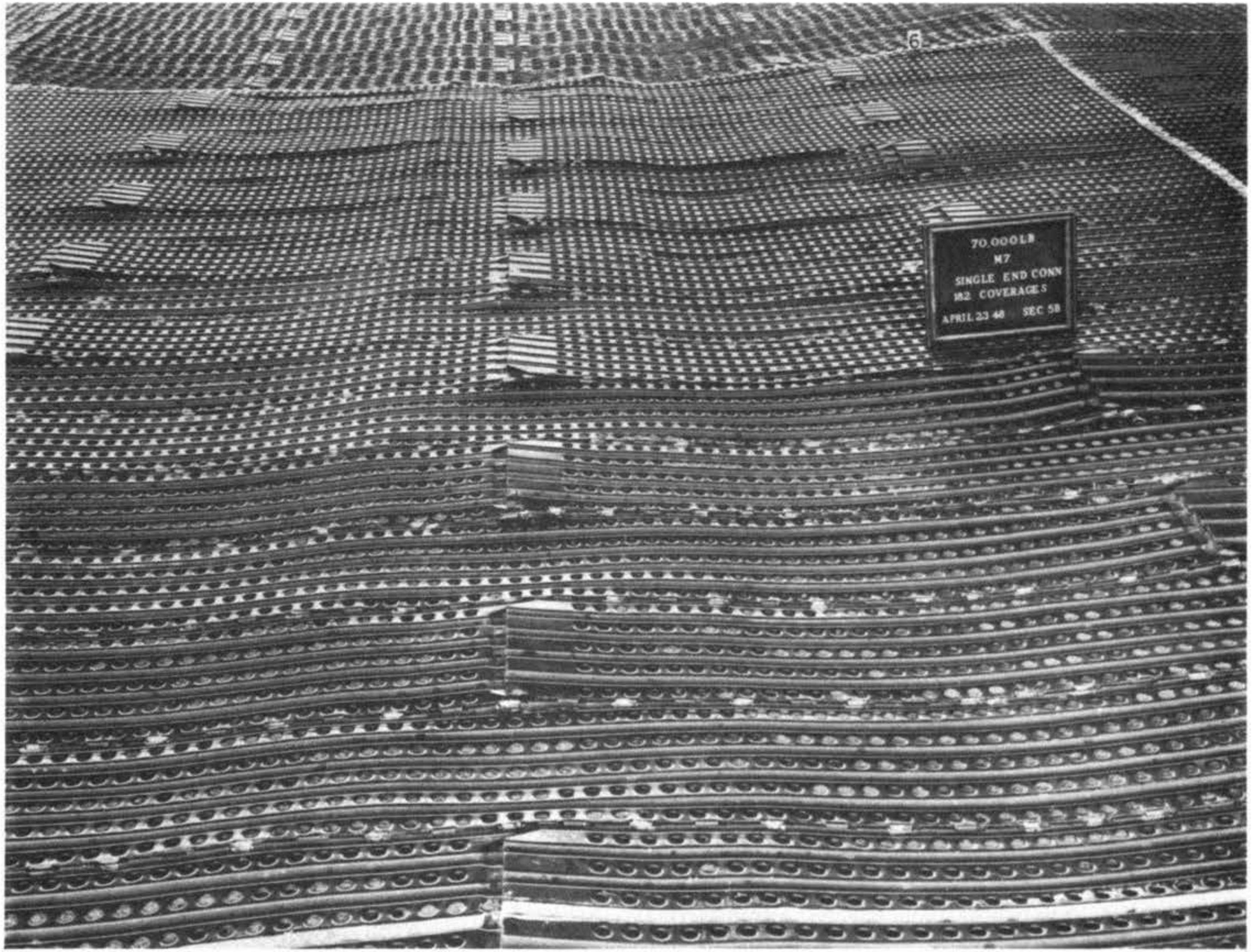
M6 mat in lane 1 after testing

PLATE 33

Appearance of PBS after removal of M7 mat at 1000 coverages

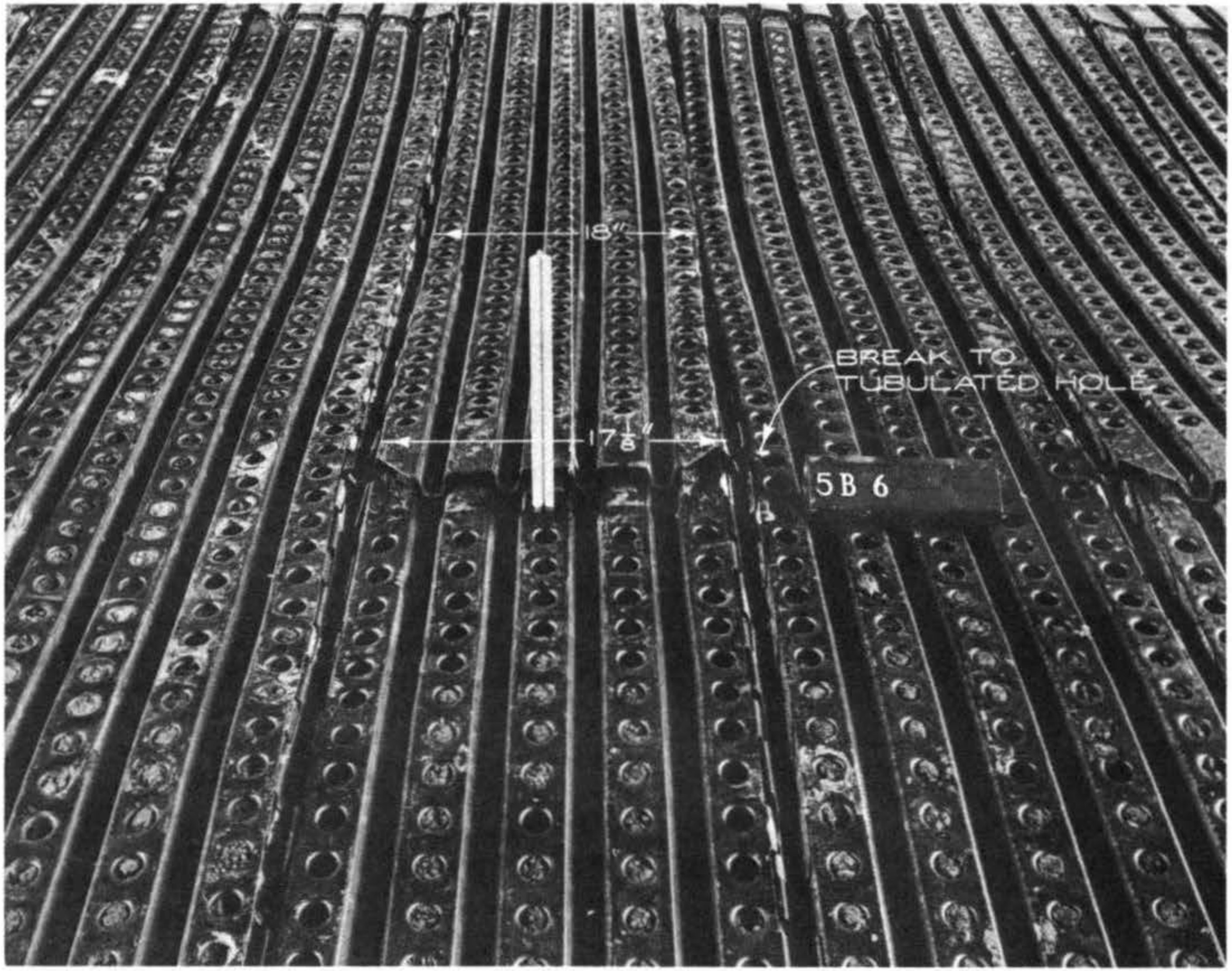
M7 mat in subsection 5b after 50 coverages

PLATE 35

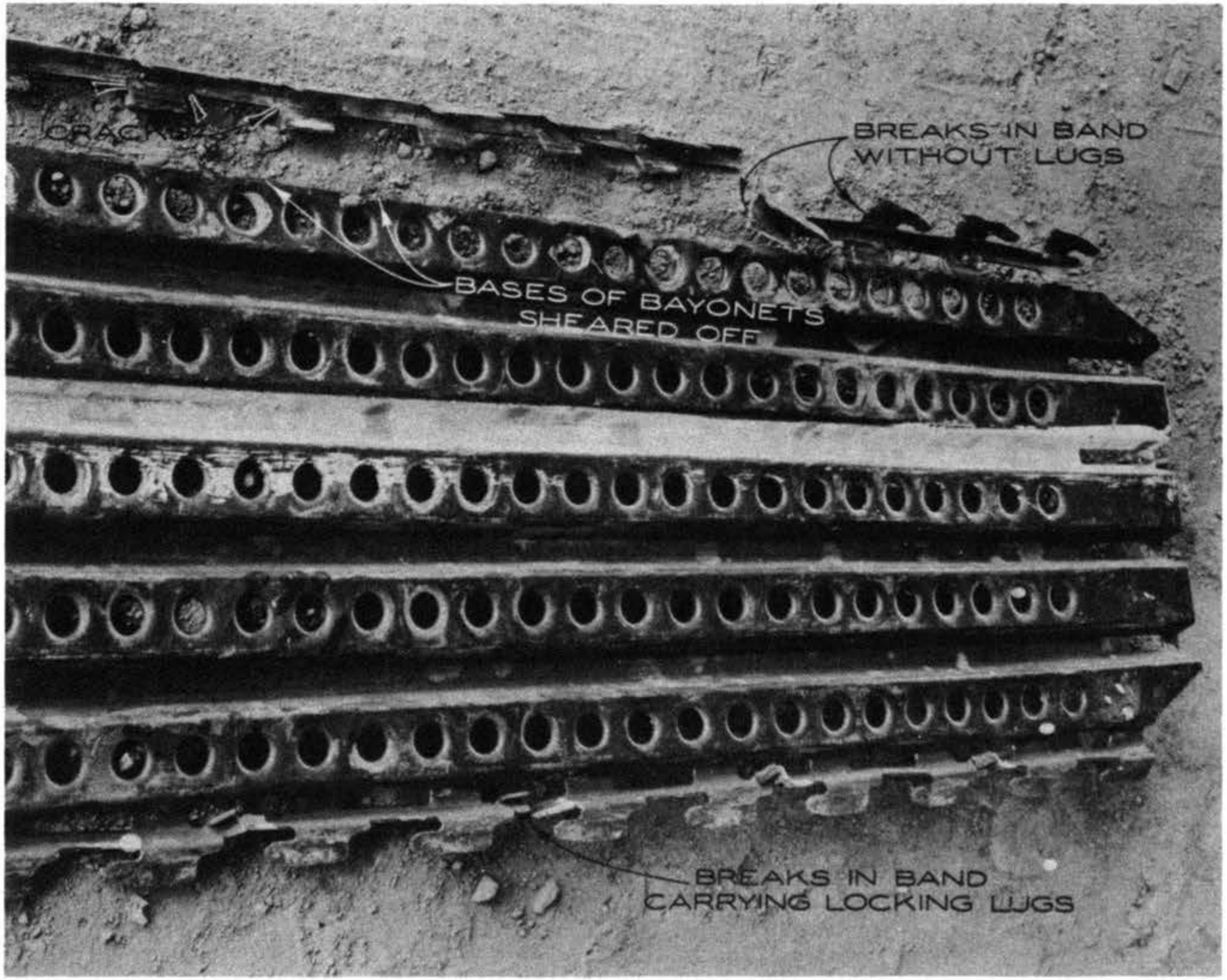


M7 mat in subsection 5b after 182 coverages

PLATE 36

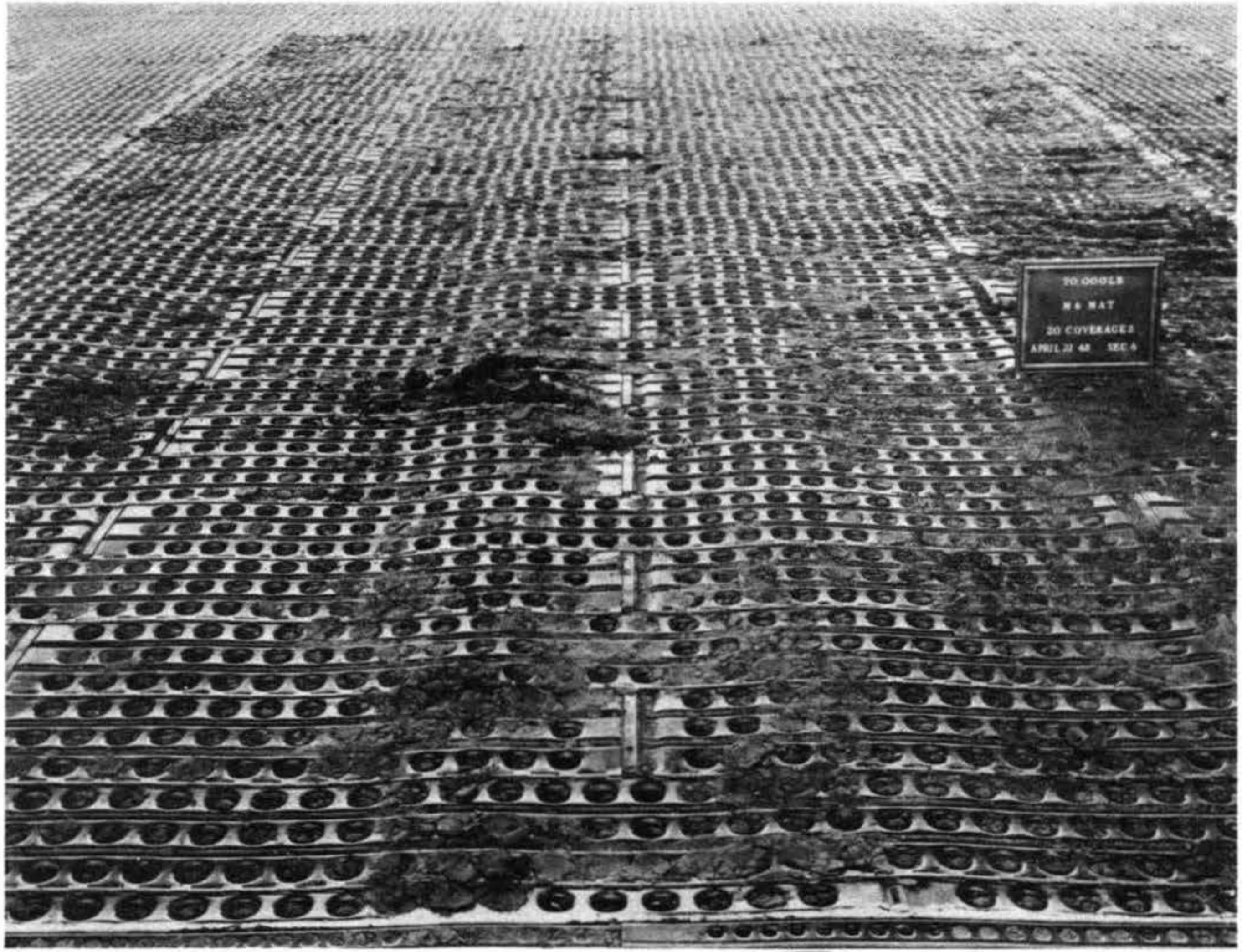


Open end joint and widened plank in subsection 5b after 182 coverages



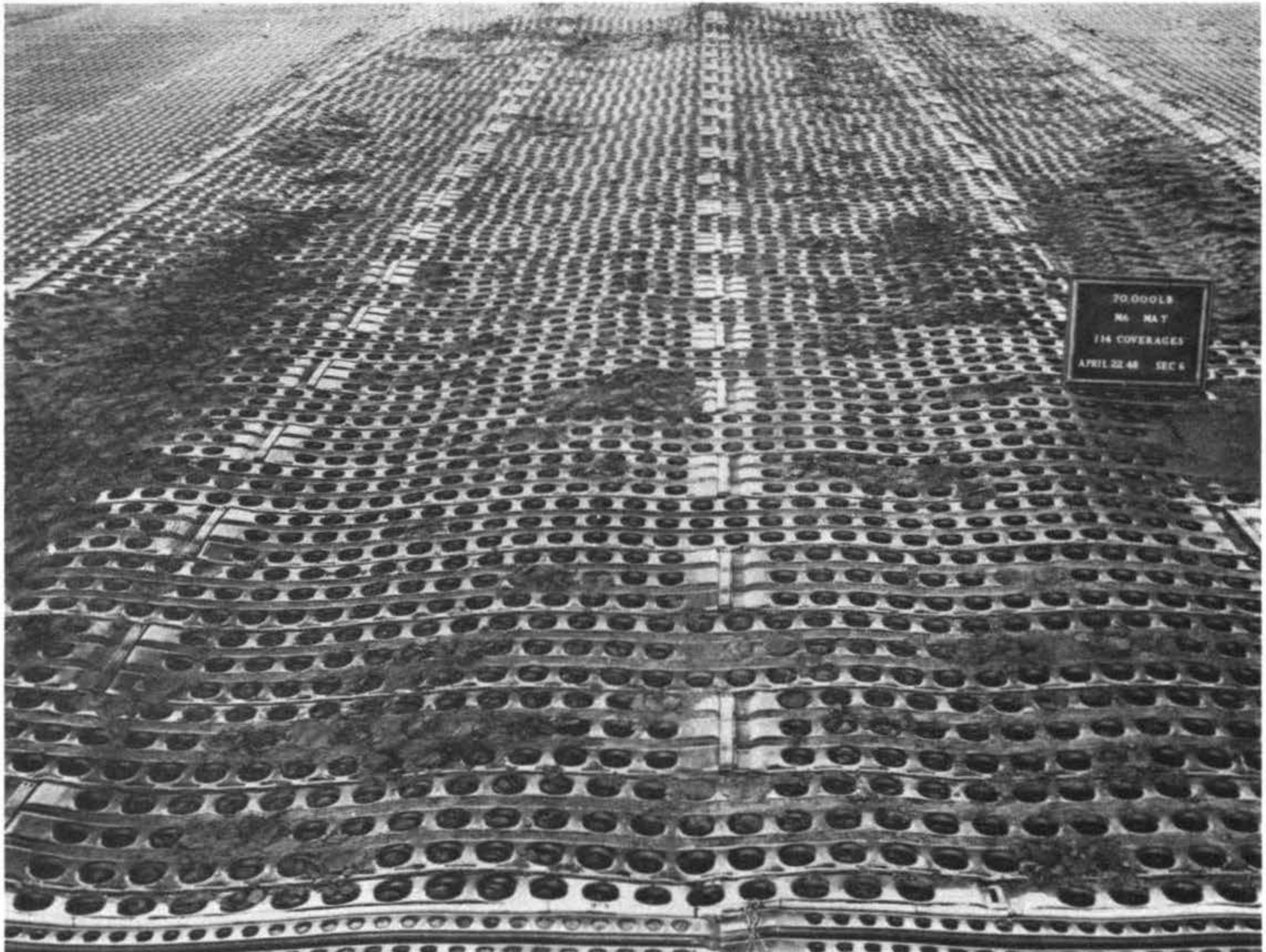
Typical breaks in M7 mat under 70,000-lb dual wheel load on weak subgrade

PLATE 38

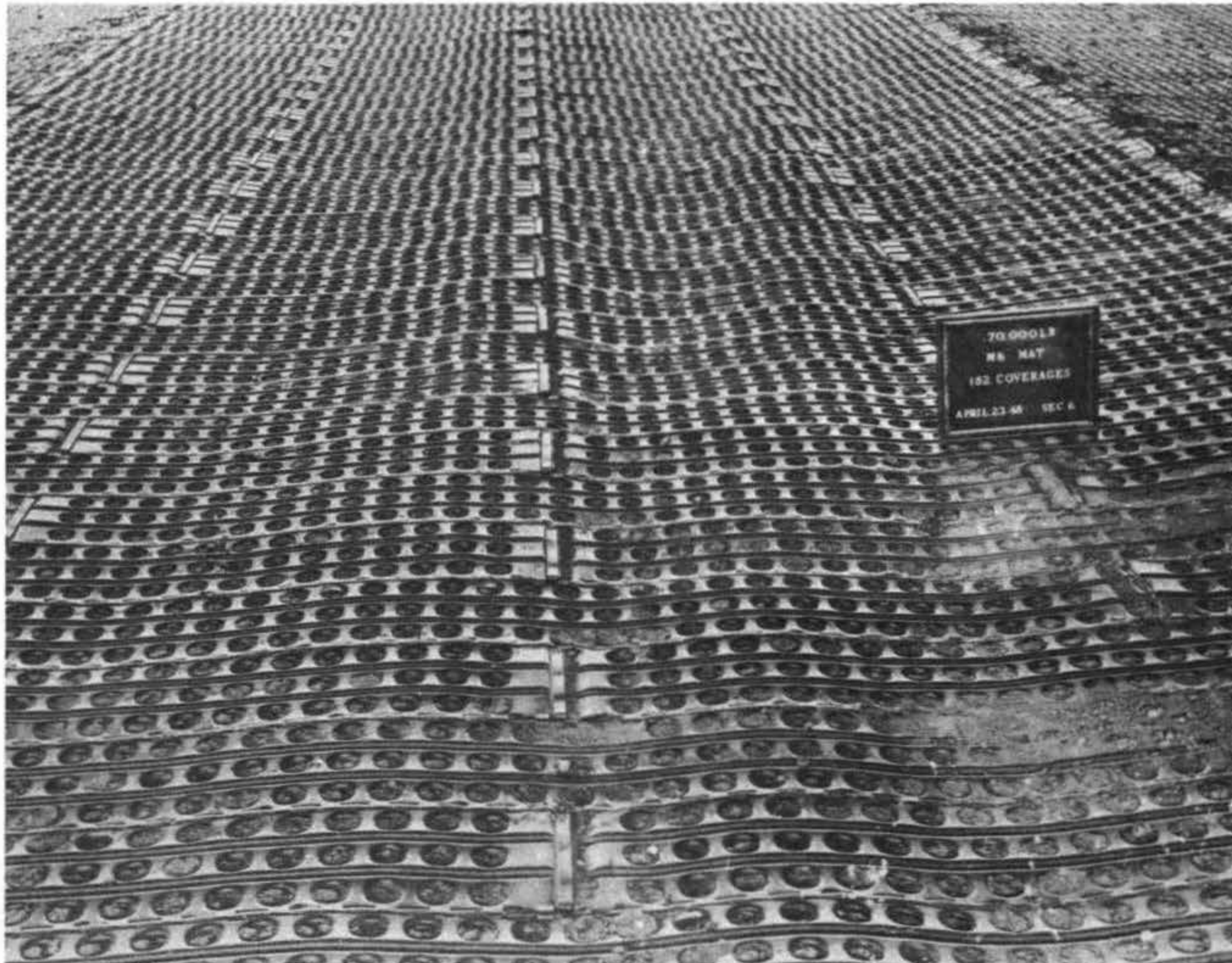


M6 mat in section 6 after 20 coverages

2 Days

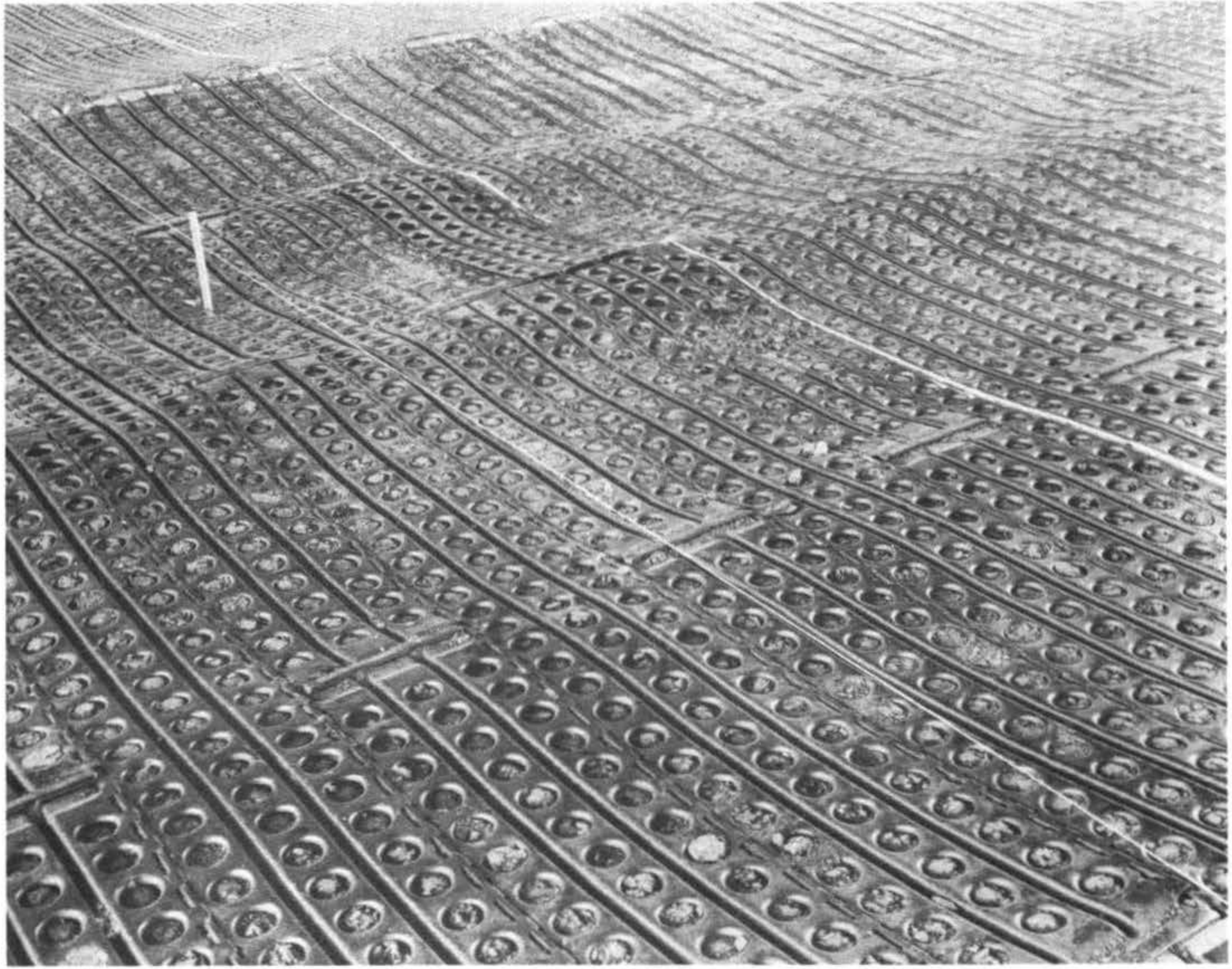


M6 mat in section 6 after 114 coverages



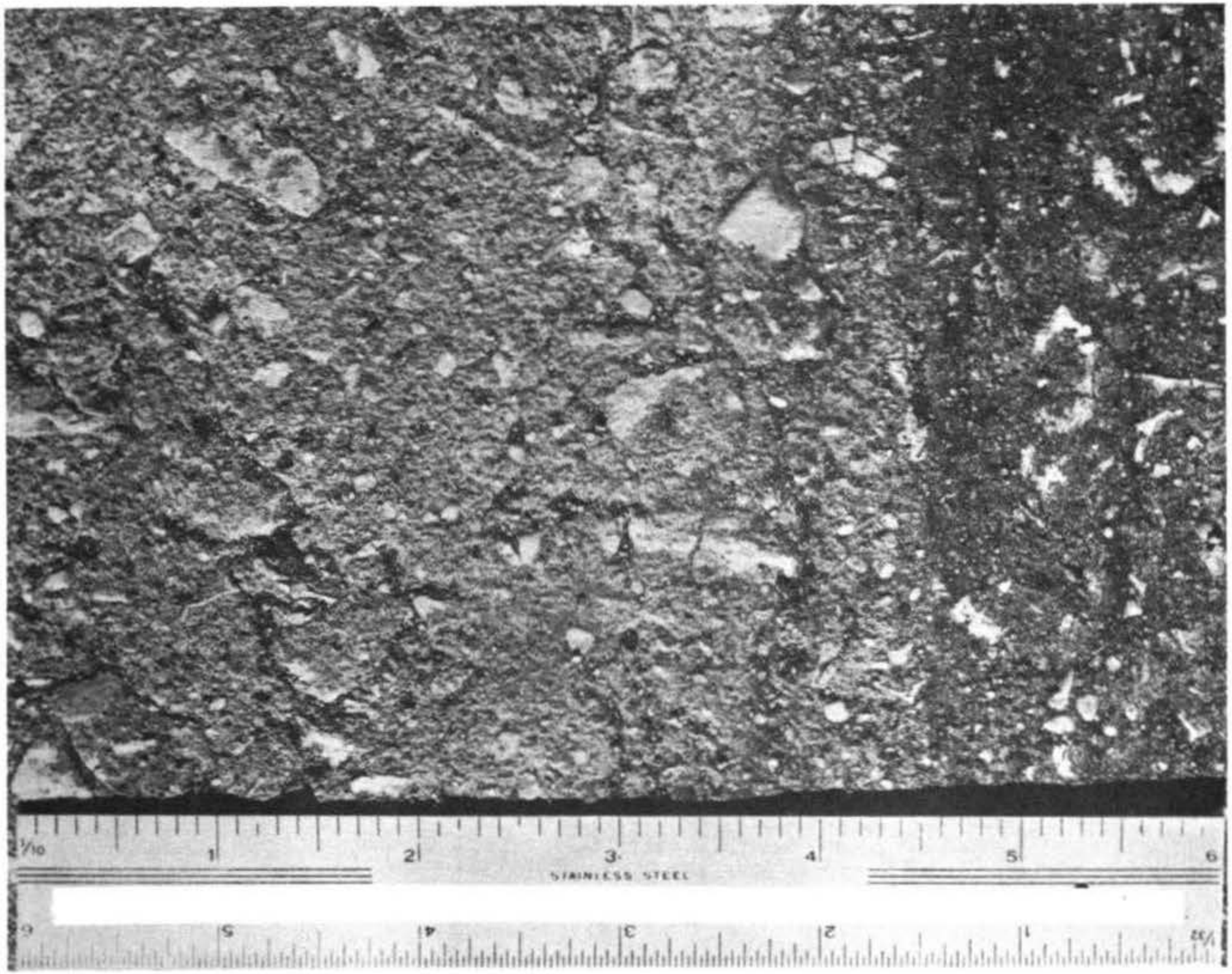
M6 mat in section 6 after 182 coverages

PLATE 41



Appearance of M6 mat surface, section 6 after 182 coverages

Appearance of M7 mat surface, subsection 5b after 182 coverages
(the half plank was removed to permit soil sampling)



Texture of asphalt pavement under tire wear test

PLATE 43

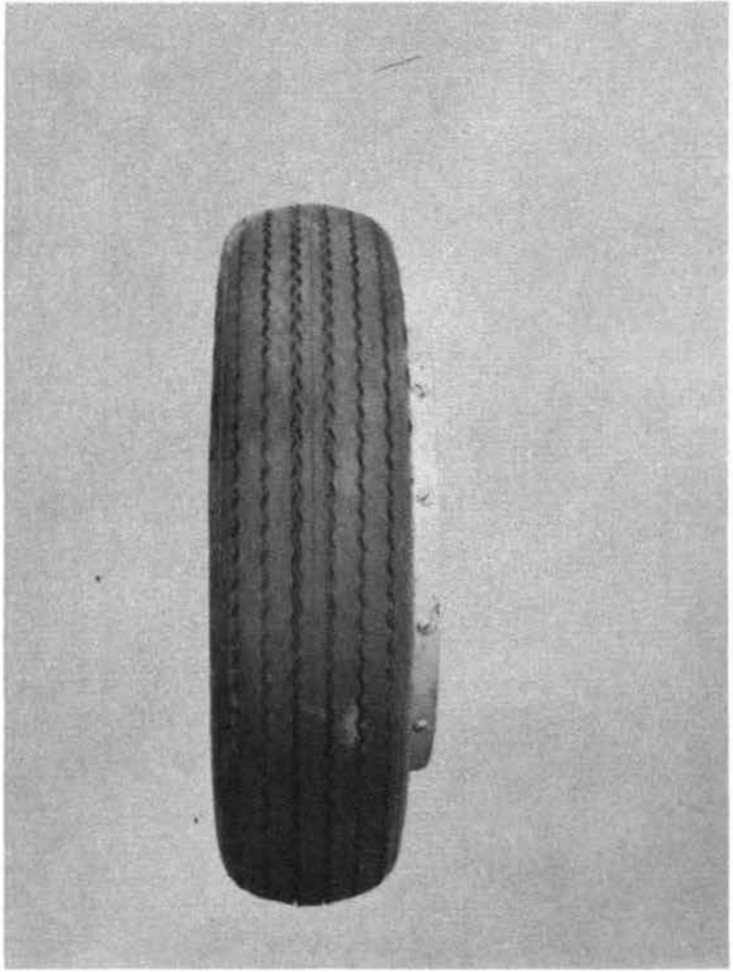


Fig. 1. Typical tire used in tire wear tests

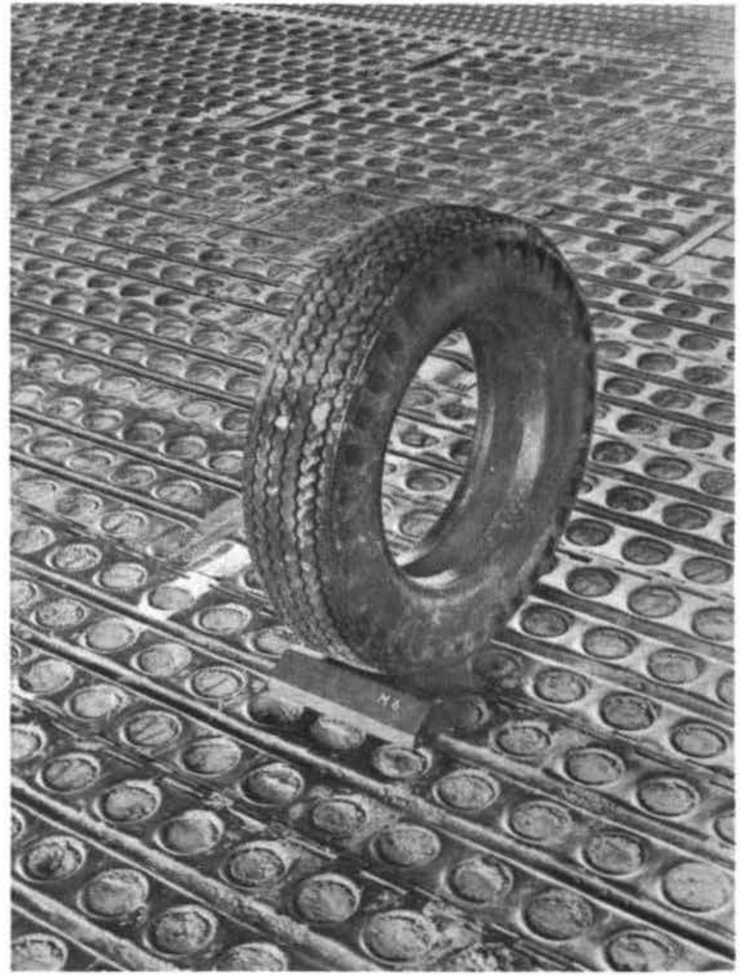


Fig. 2. Appearance of tire after test on M6 mat

Fig. 1. Appearance of tire after test on M7 mat

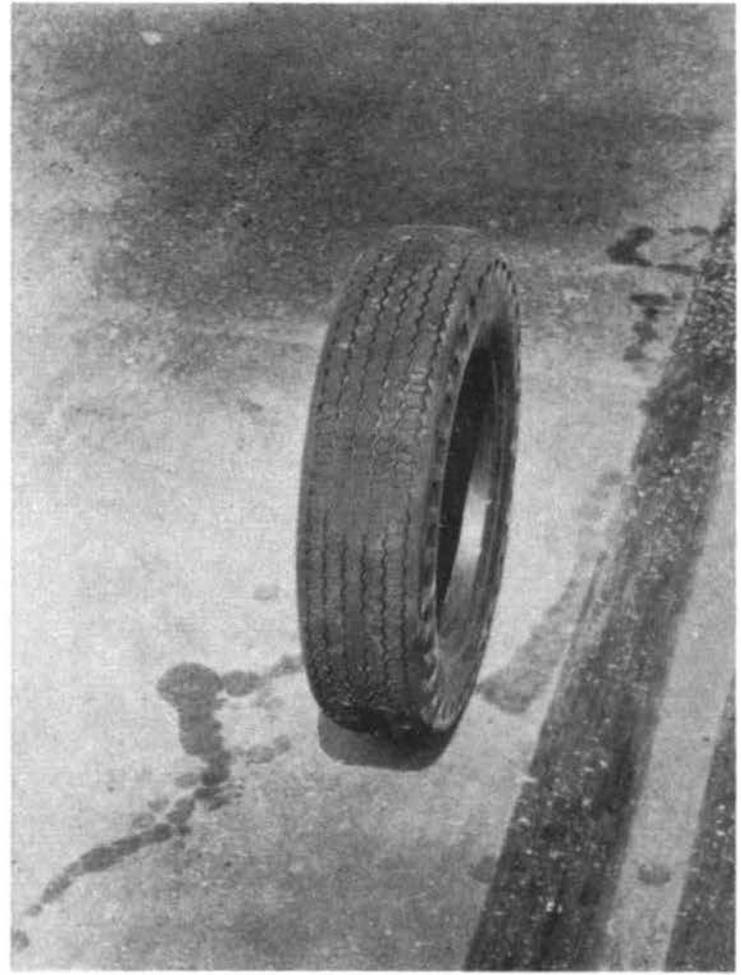


Fig. 2. Appearance of tire after test on asphalt concrete pavement

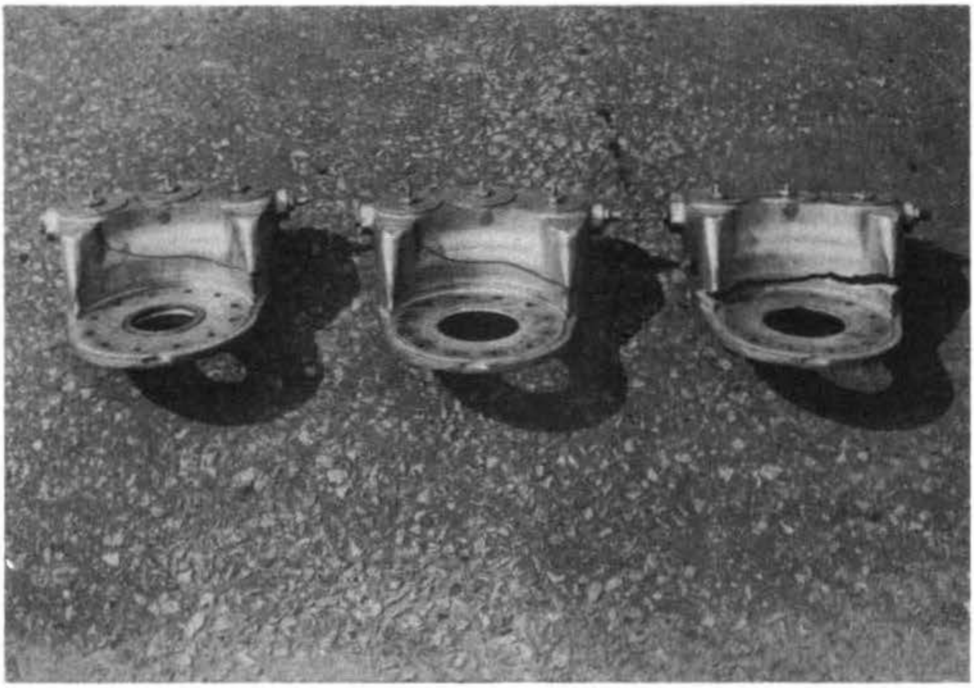


Fig. 1. Brake assemblies broken during tests

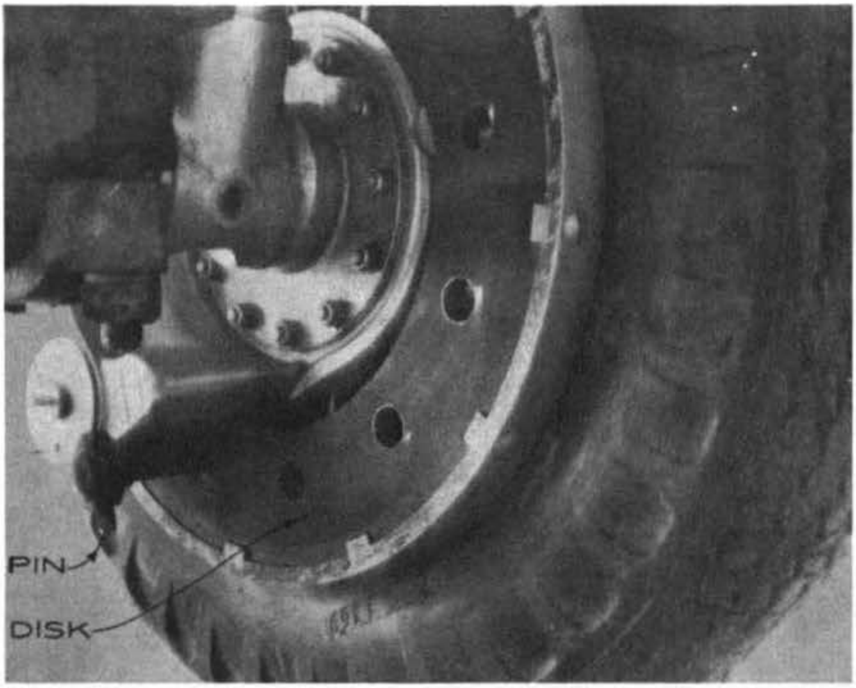
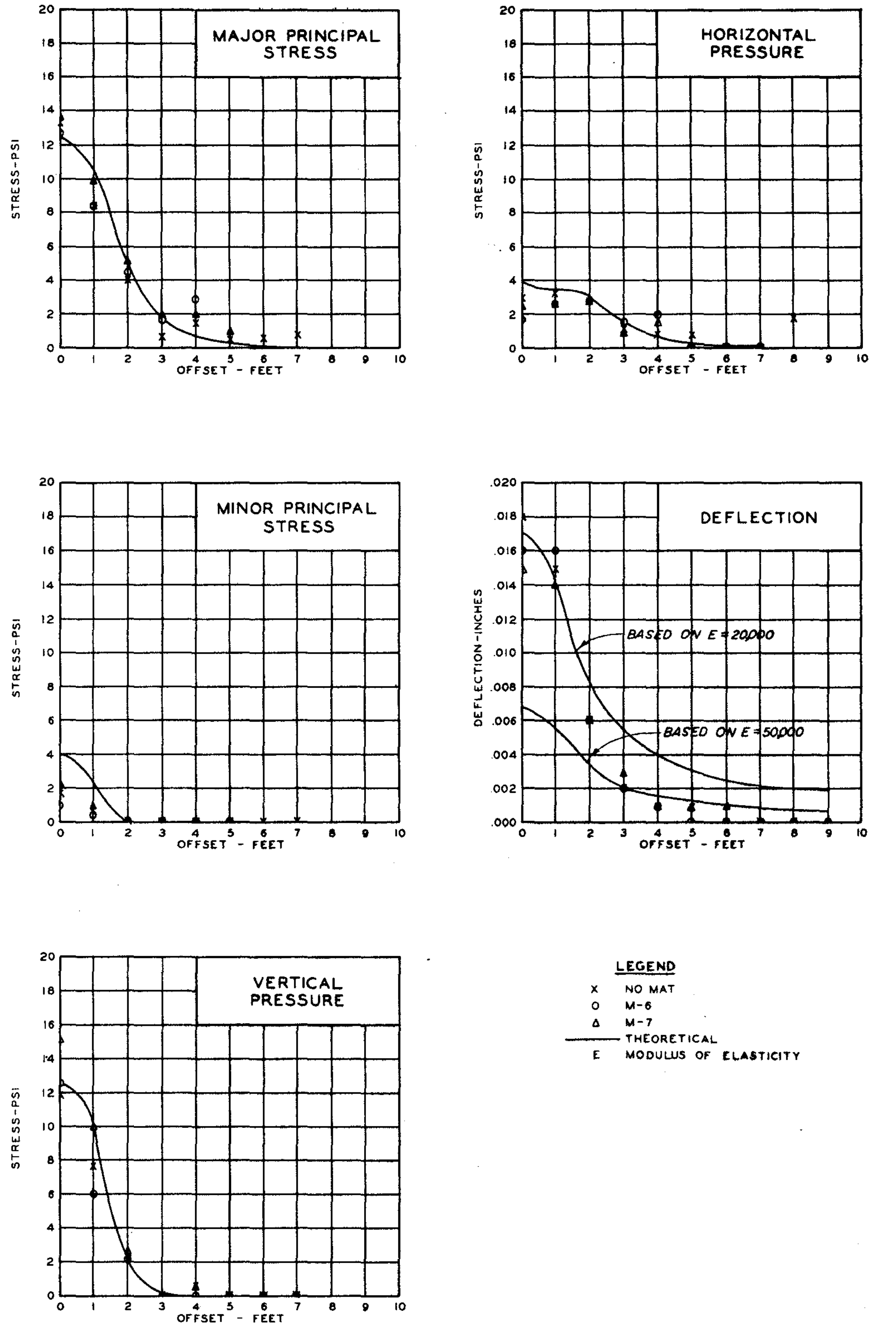
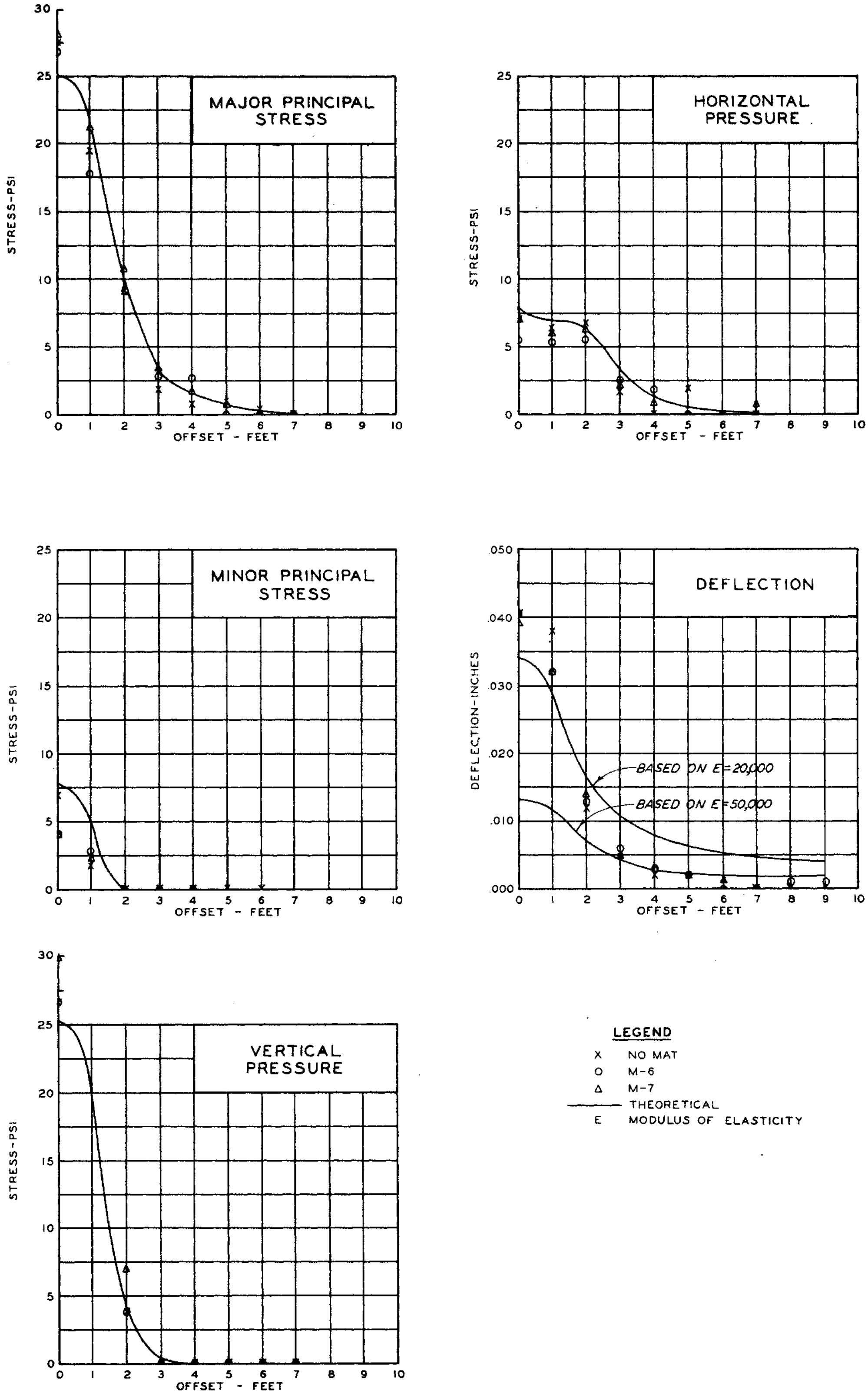


Fig. 2. Soft metal disk and pin improvised for locking wheel on asphaltic concrete



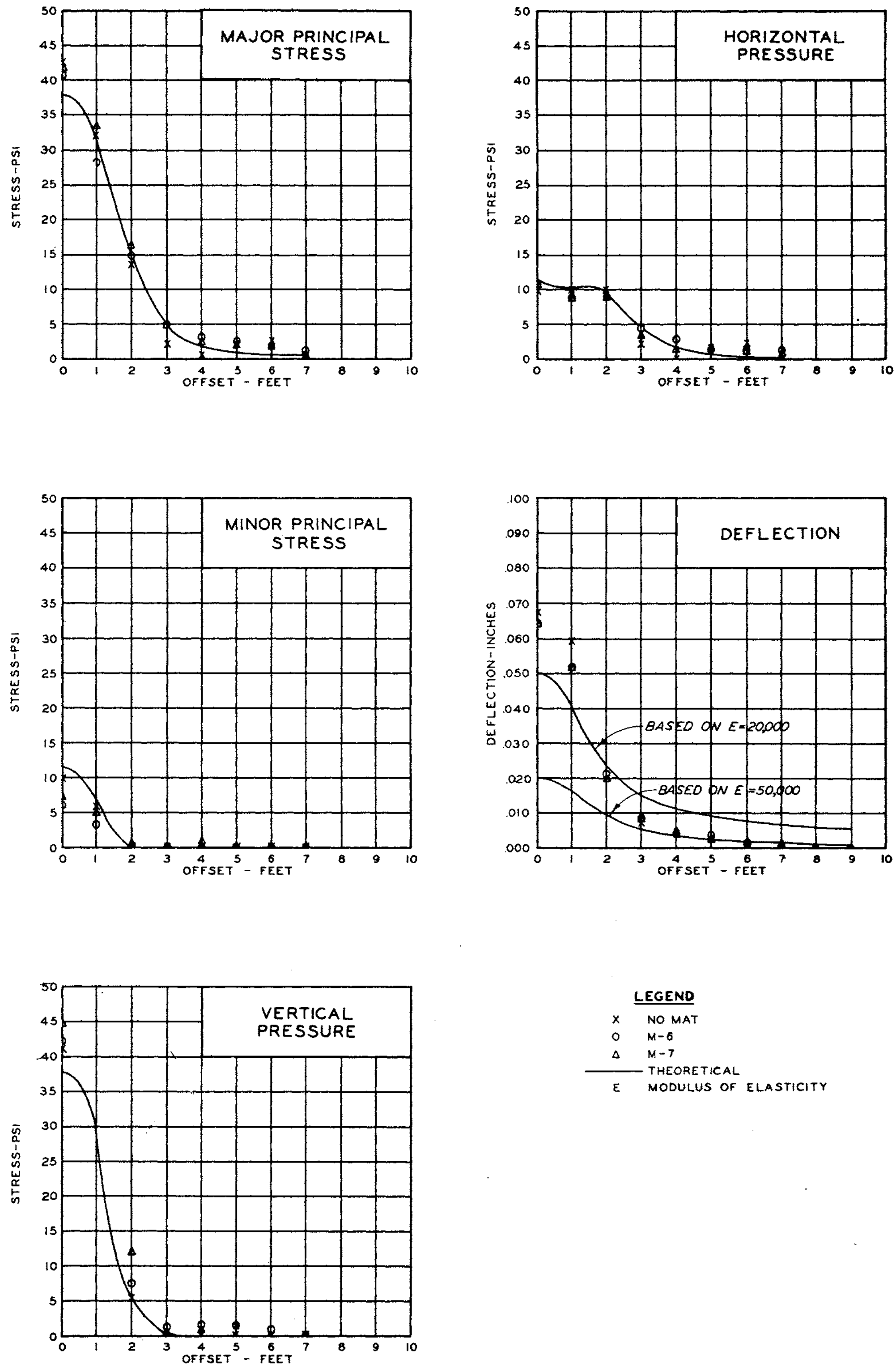
PRESSURE DISTRIBUTION UNDER LANDING MAT

15,000-LB LOAD



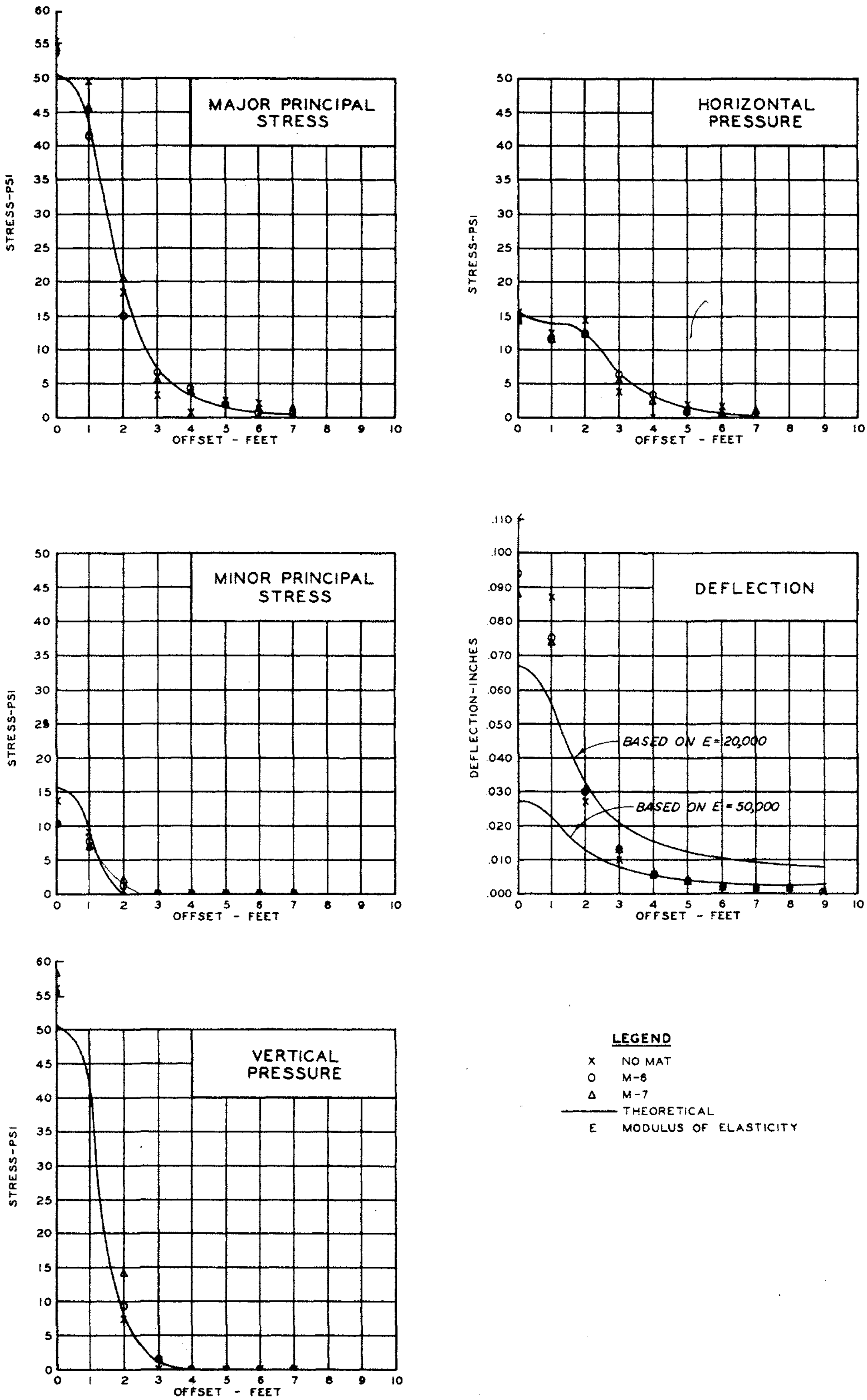
PRESSURE DISTRIBUTION UNDER LANDING MAT

30,000-LB LOAD



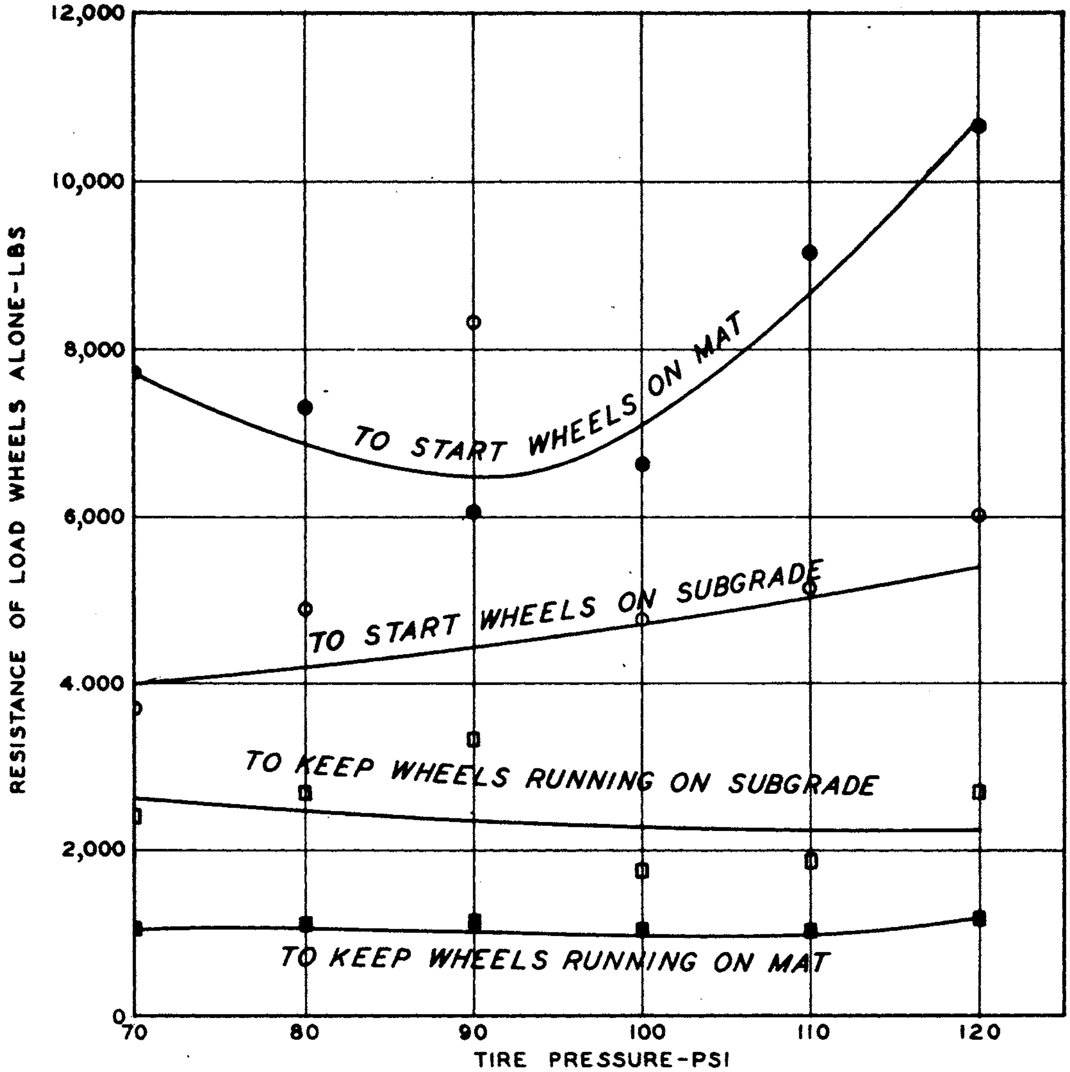
PRESSURE DISTRIBUTION UNDER LANDING MAT

45,000-LB LOAD



PRESSURE DISTRIBUTION UNDER LANDING MAT

60,000-LB LOAD



LEGEND

TO START WHEELS MOVING
○ ON 20-25 CBR SUBGRADE
● ON M7 STEEL MAT
TO KEEP WHEELS RUNNING
□ ON 20-25 CBR SUBGRADE
■ ON M7 STEEL MAT

ROLLING RESISTANCE TESTS

70,000-LB DUAL WHEELS (B-29 ASSEMBLY)

APPENDIX

Letters of Authorization and Plan of Test

Letter from Office, Chief of Engineers to Waterways Experiment Station dated 25 September 1947

Letter from Engineer Research and Development Laboratories to Waterways Experiment Station dated 29 December 1947 (With plan of tests and letter from Office, Chief of Engineers as inclosures)

Letter from Engineer Research and Development Laboratories to Waterways Experiment Station dated 31 March 1948 (With supplement to the plan of tests as inclosure)

Letter from Waterways Experiment Station to Engineer Research and Development Laboratories dated 16 April 1948 and 1st Indorsement dated 23 April 1948

WAR DEPARTMENT
Office of the Chief of Engineers
Washington

Refer to File
No. ENGNC

25 September 1947

SUBJECT: Traffic Test on M-7 Landing Mat

THROUGH: The President
Mississippi River Commission
Vicksburg, Mississippi

TO: U. S. Waterways Experiment Station
Vicksburg, Mississippi

1. The Engineer Research and Development Laboratories, Fort Belvoir, Virginia, have recommended the traffic and engineering test on the heavy duty, steel, experimental M7 airplane landing mat be conducted by the U. S. Waterways Experiment Station at Vicksburg, Mississippi. Moreover, it was stated that adequate facilities, equipment, and personnel are available at the Station for performing the test.

2. The U. S. Waterways Experiment Station is authorized to conduct the 70,000 lb. wheel load traffic test on the M7 landing mat in cooperation with Engineer Research and Development Laboratories provided that personnel, equipment and facilities are available, and that the schedule of previously planned work will not interfere with the proposed test. The M7 mat will be shipped about 1 November 1947.

3. The Plan of Test will be prepared by the Engineer Research and Development Laboratories. Reports on the test will be furnished this office and the Engineer Research and Development Laboratories.

4. Direct communication between the U. S. Waterways Experiment Station and Engineer Research and Development Laboratories on details and conduct of the traffic test is authorized.

5. All expenses incurred by U. S. Waterways Experiment Station incident to the test will be reimbursed by Engineer Research and Development Laboratories upon receipt of properly executed Form 1080.

BY ORDER OF THE CHIEF OF ENGINEERS:

/s/ R. L. Dean
R. L. DEAN
Colonel, Corps of Engineers
Chief, Engr Research & Development Div
Military Operations

ENGINEER RESEARCH & DEVELOPMENT LABORATORIES
THE ENGINEER CENTER
Fort Belvoir, Va.

TECRD T4R
400.1 (8-69-04-002)

29 DEC 1947

SUBJECT: Engineering Tests of Airplane Landing Mat, Steel, Pierced Type, M7

THRU: President
Mississippi River Commission
Vicksburg, Mississippi

TO: Director
U. S. Waterways Experiment Station
Vicksburg, Mississippi

1. Transmitted are five copies of Plan for Engineering Tests of Airplane Landing Mat, Steel, Pierced Type, M7, dated 11 December 1947. The plan has been revised and expanded to incorporate insofar as practicable, the suggestions made by your office, the Office, Chief of Engineers, and the Air Forces which were designed to improve and make more complete the original draft, dated 7 October 1947, which was submitted by this office for comment.

2. A letter from the Chief of Engineers, dated 20 October 1947, (copy inclosed) advised that the USWES is authorized to conduct the engineering tests of M7 mat for this office. It is requested therefore that the USWES conduct the tests for the ERDL substantially as outlined in the inclosed plan. The USWES will be reimbursed by this office, upon receipt of properly executed standard forms 1080, from FY 1948 funds which will be available until 30 June 1948 for expenditures incident to the tests not exceeding a total of $17,100.00. Fiscal requirements will prevent recognition of obligations made subsequent to the above date.

3. It is further requested that every effort be made to have the final report of these tests prepared and delivered to this office not later than 15 April 1948.

FOR THE COMMANDING OFFICER:

/s/ W. A. Carter
W. A. CARTER
Colonel, CE
Research Executive

2 Incls
1. Plan of Tests (in quint)
2. Ltr OCE to ERDL, 20 Oct 47

THE ENGINEER RESEARCH & DEVELOPMENT LABORATORIES
THE ENGINEER CENTER
FORT BELVOIR, VIRGINIA

18 December 1947

Plan for Engineering Tests
of
Airplane Landing Mat, Steel, Pierced Type, M7

1. Authority. Work Order No DAC 3099, dated 25 April 1946, from Chief of Engineers to President, Engineer Board, file SPENC (23 Jan 46), subject, "Development of Landing Mat for 70,000 Pound Wheel Load" which approved development project AC 680, titled, "Landing Mats, Airfield, Metal, 70,000 Pound Wheel Load," and a letter, dated 18 December 1947, from Chief of Engineers to Engineer Research and Development Laboratories, file ENGNC, subject, "Engineering Test of M-7 Landing Mat."

2. Objective. The primary objective of the tests is to determine if a single layer of Airplane Landing Mat, Steel, Pierced Type, M7, is capable of sustaining military aircraft with dual wheel loads of 70,000 pounds during one year of normal operations on field airdromes in the theater of operations. A second objective of the tests is to record data that may be used to determine whether the mat complies with the military characteristics as outlined in project AC 680 (now 8-69-04-002). A third objective of the tests is to determine the effect on M7 mat of a single wheel load of 50,000 pounds with tire inflation pressure of 200 psi.

3. Pierced Type, M7, Mat. In compliance with Work Order No DAC 3099, the Engineer Research and Development Laboratories have designed a steel landing mat (shown on Drawing E 7146-1) believed to be capable of sustaining aircraft exerting dual wheel loads of 70,000 pounds. The mat is designed to be stamped from 11 gage mild steel sheet and is basically similar to the standard pierced steel plank mat.

a. Weight. The mat is designed to weigh approximately 6.25 pounds per square foot.

b. Accessories. The design includes no accessories.

c. Connectors. The design incorporates double bayonet type side connectors with integral locking lugs and single bayonet type end connectors. Side and end connectors engage simultaneously and are so located that the bottom surface of the mat has no sharp projections to puncture any surfacing that may be used beneath the mat. After connectors are engaged the integral locking lugs are bent down to lock the connection. Model tests of this design indicated that the single bayonet type end connectors may not have sufficient strength. Accordingly, arrangements have been made to include double bayonet type end connectors on one half of the mat ordered for this test.

INCLOSURE 1

d. Top Surface. Connectors are so designed that the top surfaces of adjacent mats are in the same plane.

e. Size. The mats are approximately 21 inches wide and 12 feet long and weigh about 118 pounds. Laying width is 1 ft 6 3/4 inches, and laying length, 11 feet 8 inches.

f. Bundle Weight. Mats ordered for this test will be nested together in bundles composed of fourteen 12-foot and four 6-foot panels and each bundle should weigh about 1,900 pounds.

g. Speed of Laying. It is estimated that this mat can be laid from bundles at the edge of the runway at the rate of 100 square feet per man-hour.

h. Maintenance and Rehabilitation. One disadvantage of the design is that individual panels cannot be removed without cutting connectors, therefore, replacements must be welded in place. It is believed that a mobile plant can be designed that will successfully rehabilitate this mat.

4. Scope. To accomplish the objective, the following operations and tests will be conducted.

a. Packaging of Mat. A bundle as received from the fabricator shall be photographed against a plain background to show the bundling details.

b. Miscellaneous Data. Sufficient data shall be recorded before and during the tests so the report of tests may contain average values for the following:

(1) Nominal dimensions of a panel
(2) Weight of a single panel
(3) Laying area in square feet
(4) Weight in pounds per square foot laying area
(5) Number of panels in one bundle
(6) Square feet of laying area in one bundle
(7) Gross weight of a bundle
(8) Bundle dimensions, width, length and height
(9) Volume of one bundle in cubic feet
(10) Approximate laying speed, rate in square feet per man-hour

c. Tests. Tests as outlined below shall be performed to determine the ultimate performance of the M7 design and to supply comparative data with the earlier and lighter pierced type M6 design.

(1) Preparation of Test Area

(a) Subgrade. The tests shall be conducted at any suitable site near Vicksburg, Mississippi. An

area shall be prepared of sufficient size to accommodate two test lanes, each approximately 50 feet wide and 100 feet in length. The soil over the area selected shall be processed to provide within practicable limits a uniform, in place, California Bearing Ratio of 15% to a depth of approximately 30 inches. The plan of development for project 8-69-04-002 requires that for test purposes, the mat must sustain 1,000 coverages of a 70,000-lb rolling wheel load when laid on a subgrade with a CBR of 15 per cent. It is realized that it is impracticable to process the subgrade to exactly 15% CBR throughout the area, but for the purpose of this test it is desirable that the minimum CBR be 15% and that unavoidable variations be on the high side.

(b) Mat Test Sections. Landing mat to be tested shall be placed on the prepared subgrade, without bedding or special stretching to form two test lanes, each, approximately, 50 feet wide and 100 feet in length. Each test lane shall be divided into two sections and into subsections when required as follows:

Lane No 1

Section 1. The first section shall consist of M7 mat with the single bayonet type end connectors. The section shall be divided into two subsections a and b, approximately 50 feet wide and 25 feet in length. In subsection a all the integral locking lugs will be bent to the locked position. In subsection b one-half the integral locking lugs will be bent to the locked position.

Section 2. The second section shall consist of M6 mat.

Lane No 2

Section 3. The third section shall consist of M7 mat with the double bayonet type end connectors. Like section one this section will be divided into two subsections, one having all the locking lugs bent to the locked position and the other having one-half the locking lugs bent to the locked position.

Section 4. The fourth section shall be a duplicate of section 2 and consist of M6 mat.

The ends of sections 3 and 4 shall be thoroughly anchored to

prevent movement during braking tests.

(2) Tensiometer Tests. After the test lanes have been completed and before braking and traffic tests are conducted, tensiometer readings shall be taken while pulling the test rig described in paragraph 4c(4) below without the test wheel and weight box, and when equipped with the dual tired B-29 main landing wheel loaded to 70,000 pounds, on the M7 mat and on 15 CBR soil. Readings shall be taken with test tires at 10 pound per square inch inflation increments, between the inflation pressures of 70 to 140 psi. Tires on the test rig other than those on the test wheel shall be maintained at a constant pressure during these tests.

(3) Braking Tests. Braking tests shall be conducted on both sections of Lane No 2, both before traffic testing has been started, and after the mat has become bedded in the subgrade. The tests shall consist of pulling the test rig equipped with a dual tired B-29 main landing wheel over the test lane along its longitudinal centerline and applying the brakes until the loaded wheel slides on the mat. It is desirable during braking tests, if practicable, that the equipment be towed by cable or other means to eliminate the possible restraining action of a towing tractor on the mat under test.

(4) Traffic Tests. Rolling wheel loads shall be applied by a testing rig as described in a bulletin dated July 1945 and titled "Runway Load Testing Device, Designed and Constructed Under the Supervision of the Corps of Engineers, U. S. Army, Pittsburgh District."

Lane No 1. A traffic lane covering approximately the center one-third of test lane No 1 shall be tested to 1,000 coverages, or failure of the M7 mat, by uniform coverages of a 70,000 pound wheel load. The testing wheel used shall be a dual tired B-29 main landing wheel with 56-inch diameter tires. The wheel shall be loaded to 70,000 pounds and the tires inflated to provide a 23.33 inch rolling radius.

Lane No 2. A traffic lane covering approximately the center one-third of test lane No 2 shall be tested to 1,000 coverages, or failure of the M7 mat by uniform coverages of a 50,000 pound wheel load. A 56 x 16 tire and wheel shall be used as the testing wheel and the tire shall be inflated to 200 psi. The Air Forces, Air Materiel Command will furnish the tire, tube,

wheel and brake equipment. The wheels and brakes are Bendix Products Division part Nos 146458 and 146403 respectively. Casing will conform to Air Materiel Command drawing No S47R1231, and inner tube to Air Materiel Command drawing No S45J204.

(5) Stress Distribution Tests. It is understood that a test section containing soil with a CBR of 10 and a complete installation of pressure cells and deflection gages constructed for another test will be available at USWES about 1 January 1948. This test section will be utilized to obtain comparative data on the load distributing value of the two mat types.

(6) Removal and Replacement Test. At a convenient time during traffic testing, but after the mat has been subjected to considerable traffic, a single panel of M7 mat shall be removed and replaced by a new panel in order to determine the difficulties involved and a reasonable solution thereof.

5. Test Data.

a. Soil Tests. Sufficient tests shall be made to identify the soil used for subgrade and to insure a subgrade bearing value within the requirements of paragraph 4c(1)(a) above.

b. Tensiometer Tests. Sufficient readings shall be taken as described in paragraph 4c(2) above to provide a comparison of the rolling resistance of the loaded wheel on the M7 mat and on 15 CBR soil at the various tire inflation increments.

c. Braking Tests. Effect of braking tests shall be recorded by photographs and by recording the amount of mat movement and/or other pertinent information.

d. Tire Wear. Photographs and a description shall be obtained of any unusual tire wear or damage occurring during the various tests, together with a history of the tire operation.

e. Tire Track. Photographs shall be taken of the static tire print and of the tire track left by the 70,000 pound and 50,000 pound rolling test wheels, on the M6 mat, the M7 mat and the 15 CBR soil without surfacing.

f. Pressure Readings. Utilizing the test section mentioned in paragraph 4c(5) above, and applying the loads through a single 500 square inch circular plate with a flexible face, the stresses and deflections induced in the subgrade at a depth of 12 inches by 17,500, 37,000, and 70,000 pound loads shall be measured with no mat over the surface, with M6 mat over the surface, and with M7 mat over the surface. Sufficient

measurements shall be made to develop profiles along the longitudinal and transverse centerlines of the mat panels.

g. Speed of Laying. A record shall be kept of the time required for placing the test section and a comparison made as to ease of placing the two types of mat.

h. Miscellaneous Test Data. Measurements shall be recorded, at the first pass of the testing equipment, of the average deflection of the two types of mat under the loaded dual wheel. Like information shall be recorded after the mat has become well bedded due to traffic. Surface elevations of the various test sections shall be recorded at frequent intervals both before and after the traffic tests. Frequent inspections of the mat shall be made during the tests and its condition recorded in detail. Photographs shall be taken to adequately illustrate the written record of the tests.

6. General. The U. S. Waterways Experiment Station, Vicksburg, Mississippi, will conduct the tests for the Engineer Research and Development Laboratories and furnish all direct supervision, labor, construction equipment, tools testing equipment and incidentals necessary to construct the test sections, conduct the tests and report thereon. The Pierced Type M6 landing mat is available from Engineer Research and Development Laboratories stocks now at Vicksburg. The Pierced Type M7 mat has been shipped and should be available at Vicksburg by the time this plan is received. It is desired that the tests be conducted substantially as outlined herein. However, minor changes or additions may be made as indicated during progress of the tests. Changes of a major nature will be made only after concurrence by the Engineer Research and Development Laboratories.

7. Disposition of Mat after Test. Undamaged M7 mat from the edges of the test sections shall be removed and stored for future use in comparative engineering tests contemplated in the future with an aluminum alloy mat similar in design to the M7 steel mat. Undamaged M6 mat shall also be removed and stored for use in future tests. Damaged mat of both types may be utilized by the USWES or turned in for salvage at the discretion of that agency.

8. Reports. Brief bi-weekly progress and cost reports will be prepared and forwarded to the Engineer Research and Development Laboratories during the periods of preparing the area and conducting the tests. One information copy of progress reports will be forwarded to Engineer Research and Development Division, OCE. It is requested that these reports be identified by project No 8-69-04-002 and W. O. No DAC 3099. Upon completion of the tests, a comprehensive final report with conclusions will be prepared and forwarded to the Engineer Research and Development Laboratories.

WAR DEPARTMENT
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON

ENGNC

20 October 1947

SUBJECT: Engineering Test of M7 Heavy Duty Airplane Landing Mat

TO: The Commanding Officer
Engineer Research and Development Laboratories
Fort Belvoir, Virginia

1. Reference is made to the 1st Indorsement from this office to Engineer Research and Development Laboratories, dated 26 September 1947, file ENGNC, subject: Engineering Tests of Airplane Landing Mat, Steel, Pierced Type M7. Paragraph 1 stated that the U. S. Waterways Experiment Station had been authorized to conduct the 70,000 lb. wheel load traffic test provided that adequate personnel, equipment and facilities were available for same.

2. This office has been advised by the U. S Waterways Experiment Station that adequate personnel, equipment and facilities are available and that the M7 mat test will not interfere with their previously scheduled work.

3. Attention is invited to paragraph 3 of the above referenced indorsement, wherein direct communication between the Engineer Research and Development Laboratories and the U. S. Waterways Experiment Station on matters pertaining to this test is authorized.

4. It is requested that a copy of the plan of test, prepared by Engineer Research and Development Laboratories, be submitted to this office.

BY ORDER OF THE CHIEF OF ENGINEERS:

/s/ R. L. Dean
R. L. DEAN
Colonel, Corps of Engineers
Chief, Engr Research & Development
Div
Military Operations

INCLOSURE 2

ENGINEER RESEARCH AND DEVELOPMENT LABORATORIES
THE ENGINEER CENTER
Fort Belvoir, Va.

In Reply TECRD T4R
Refer To: 400.1 (8-69-04-002)

31 Mar 1948

SUBJECT: Supplement to Plan for Test of M7 Mat

TO: Director
U. S. Waterways Experiment Station
Vicksburg, Mississippi

1. Transmitted are five copies of Supplement to Plan for Engineering Test of Airplane Landing Mat, Steel, Pierced Type, M7, dated 23 March 1948.

2. It is requested that the tests outlined in the Supplement be performed along with other engineering tests of M7 landing mat covered by the original plan of tests transmitted with letter from this office, dated 29 December 1947. Funds in the amount of $3,200 in addition to the $17,100 authorized by the letter dated 29 December 1947, and $7,400 authorized by 1st Ind dated 11 March 1948, are available, until 30 June 1948, to reimburse the USWES for cost of tests added by the inclosed Supplement.

FOR THE COMMANDING OFFICER:

1 Incl
Supplement (in quint)

/s/ Frank A. Gleason
FRANK A. GLEASON
Major, CE
Acting Research Executive

THE ENGINEER RESEARCH & DEVELOPMENT LABORATORIES
THE ENGINEER CENTER
FORT BELVOIR, VIRGINIA

23 March 1948

Supplement
To
Plan for Engineering Test
Of
Airplane Landing Mat Steel, Pierced Type, M7
Dated 18 December 1947

1. To paragraph 4c add subparagraph (7) as follows:

(7) Tire Wear Tests. The relative rates of wear of 26 in. by 6.6 in. aircraft tires operating at 8,000 pound load and at 160 psi inflation pressure shall be determined under braking conditions on M6 and M7 landing mats and on asphalt pavement. The wear test shall consist of pulling the locked loaded wheel across each type of surface (in the most severe location and direction) a distance of 1,000 feet. The test wheel shall be rotated slightly every 50 feet to prevent excessive wear at one spot on the tire. A new tire shall be used on each different type of surface.

2. To paragraph 5d add the following sentence: In connection with special wear tests of 26 in. by 6.6 in. tires described in paragraph 4c(7), the tires shall be weighed before and after the tests to determine the relative rates of wear.

INCLOSURE 1

WAR DEPARTMENT
CORPS OF ENGINEERS
Office of the President
MISSISSIPPI RIVER COMMISSION
Vicksburg, Mississippi

Refer to: LMWSF

16 April 1948

SUBJECT: M-7 Landing Mat Tests

TO: The Commanding Officer
Engineer Research and Development Laboratories
The Engineer Center
Fort Belvoir, Virginia

1. In accordance with requests made by Messrs. Schoolcraft and Spangler during their recent visits to the Waterways Experiment Station, there are furnished herewith cost and time estimates for additional tests.

2. The need for additional tests is occasioned by the fact that no failures occurred during tests with the 70,000-lb dual wheel load. The subgrade in the existing section, which had a CBR of approximately 15 per cent at the start of traffic, was so strong that no failures occurred. Mr. Spangler suggested limited additional tests on a subgrade weak enough to produce failures so that a comparison could be obtained between the new M-7 mat and the old M-6 mat which is being used as a control.

3. In discussions on 7 April agreement was reached on a program as outlined below. The program was discussed on 9 April with Mr. Schoolcraft and it was acceptable to him. The program will consist of the following:

a. Construct a new section on the old lane 2 with a subgrade having a CBR of about 10 per cent (any deviations to be on the low side) to a depth of 18 inches.

b. Transfer the mat now on lane 1 to the new section. This mat is in good condition.

c. Apply traffic with the 70,000-lb dual wheel load until failure occurs or until 500 coverages are applied.

d. Conduct the necessary CBR, moisture, and density tests before and after traffic.

4. An estimate of cost was given to Mr. Spangler and was tentatively approved by him. This estimate contemplated continuing the tests without interruption. The estimate was discussed with Mr. Schoolcraft on 9 April and was acceptable to him. Since the scheduled tests on the M-7 mat were completed on 8 April, Mr. Schoolcraft gave verbal approval to start the additional program described in paragraph 3 above. Construction of the new section was initiated on 9 April. The costs of the work outlined in paragraph 3 are estimated as follows:

Construction of Section	$2400
Changing mat	600
Traffic testing	1800
CBR testing	480
	$5280

5. The additional tests will require about 16 working days and should be completed by approximately 30 April 1948. In the revised estimate submitted to your office on 26 February it was contemplated that all testing would be completed by 6 April and the draft of the report furnished your office by 6 May. Since testing will continue until 30 April, it will be necessary to extend the date for furnishing the report until 28 May to include the data from these additional tests.

R. D. KING
Lt. Col., Corps of Engineers
Director